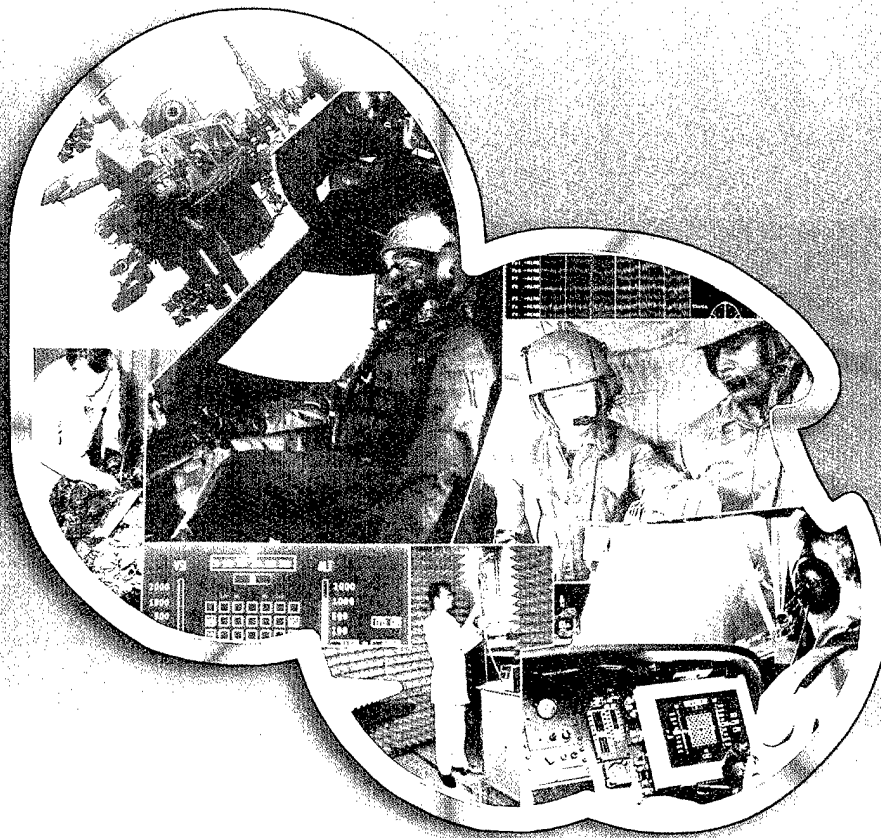


**USAARL Report No. 2003-02**

# **A Comparison of AH-64D and OH-58D Pilot Attitudes Toward Glass Cockpit Crewstation Designs**

**by Gregory Francis (Purdue University) and Clarence E. Rash, Gina E. Adam, Patricia A. LeDuc, and Stefanie L. Archie (USAARL)**



**Aircrew Health and Performance Division**

**November 2002**

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## Introduction

Computers and multifunction displays (MFDs) are an integral part of several current Army rotary-wing aircraft. The cockpit design with these types of systems is sometimes called the "glass cockpit." MFDs and computers are also an integral part of the cockpit designs for planned future aircraft. A recent study by Rash et al. (2001) noted that aircraft with a glass cockpit design have higher accident rates than corresponding aircraft with the traditional cockpit design. This finding suggested that the details of crewstation design needed to be examined. To identify significant differences, this study assessed pilots' attitudes toward glass cockpit designs in the AH-64D Apache and OH-58D Kiowa helicopters. The study compared the opinions of pilots in these two glass cockpit designs to identify which aspects of their respective cockpits were most favorable or troublesome to the pilots. The results of the study identify which areas of cockpit design require further investigation.

## Background

The crewstation instrument panel of aviation cockpits is undergoing radical change. Computers and MFDs now replace many traditional displays of gauges and dials. The new design is sometimes referred to as a "glass cockpit" to indicate the presence of computer screens in the MFDs on the crewstation instrument panel. The development of glass cockpit designs was seen as necessary to reduce the clutter of traditional cockpit designs and to provide the aircraft with enhanced capabilities that would not fit into the traditional cockpit design (e.g., Silverio and Drennen, 1985). Glass cockpit designs are part of many new aircraft, both in commercial and military aviation. The U. S. Army has integrated the glass cockpit scheme into four rotary-wing aircraft types: the AH-64 Apache, the CH/MH-47 Chinook, the OH-58 Kiowa, and the UH/MH-60 Black Hawk. The glass cockpit models of these aircraft are designated as the AH-64D, MH-47E, OH-58D, and MH-60K, respectively. In addition, the MH-47D and MH-60L have crewstation configurations that are referred to in the industry as hybrids because they mix MFDs and dedicated instruments. The distinction between a glass cockpit and a hybrid configuration is not simple because all glass cockpits models also include some dedicated instruments. The term glass cockpit refers to the importance of MFDs and computer displays in the cockpit. Different glass cockpit crewstation designs can have very different physical appearances, as Figure 1 shows. Moreover, even with identical physical appearances, two glass cockpit systems can be dramatically different due to the information content and the software interface used to retrieve and display the information.





Figure 1. Views of the OH-58D cockpit design (left) and the AH-64D glass cockpit design (right).

Flying an aircraft is a highly specialized task that requires crewmembers to learn a large set of skills to operate with the visual displays and instruments. Pilots fly differently with glass cockpit and traditional designs. For example, Degani, Chappell and Hayes (1991) studied incident reports where crewmembers of commercial fixed wing aircraft detected a potentially dangerous situation and implemented appropriate measures to avoid an accident. The study demonstrated that the flight crew in a glass cockpit design was more likely to detect a potential problem than the flight crew in a traditional design (most of the other detections of incidents were made by air traffic controllers). On the other hand, several studies have noted problems and concerns about glass cockpit designs in commercial aviation (e.g., Funk and Lyall, 1997; Wiener, 1989; Wiener and Curry, 1980; Sarter and Woods, 1995). Common concerns are that computer automation introduces pilot boredom and reduces situational awareness. Despite the concerns, pilots generally approve of the introduction of glass cockpit designs, and there is significant evidence that commercial aircraft with a glass cockpit design have fewer accidents that lead to hull loss (Funk and Lyall, 1997).

The effect of glass cockpit designs in military rotary-wing aviation has not been investigated as fully as in the commercial sector. Glass cockpit designs in rotary-wing military aircraft do not introduce nearly the level of automation that is used by fixed wing commercial aircraft, so many of the concerns about pilot boredom in commercial aircraft may not transfer to the military rotary-wing pilots. Given the dramatic differences between the pilots' roles in commercial and military situations, it may be inappropriate, without some outside justification, to apply conclusions from one sector to the other.

The different purpose and function of glass cockpits in fixed wing commercial and rotary-wing military aircraft seem to be represented in some data sets. Although there is convincing evidence that glass cockpit designs lead to fewer accidents in fixed wing commercial aircraft (Funk and Lyall, 1997), the same does not seem to be true for military rotary-wing aircraft. Rash et al. (2001) compared accident rates for Army rotary-wing aircraft that have both traditional and

glass cockpit models. The accident rate for the OH-58 was much higher for the glass cockpit version of the aircraft than for the traditional version (statistical analyses confirmed that the difference was significant). Similar results were found for the AH-64, the UH-60, and the CH-47, although the flight-hour data for the glass cockpit designs were too small to reach statistical significance. Contrary to the commercial sector, in these military aircraft there was no improvement in overall safety with the introduction of a glass cockpit design.

Also, there are discrepancies between the expected characteristics of the glass cockpit design and some pilots' impressions. A formal investigation of the preliminary airworthiness of the OH-58D (Bender et al., 1984) predicted that workload levels would be manageable, except for a few specific situations. Low workload is also the first listed feature of the OH-58D in a product brochure produced by its manufacturer (Bell Helicopter Textron Inc., 1988). In contrast, two Army OH-58D pilots (Ramsey and Altman, 1998) speculated that the glass cockpit design in the OH-58D results in task overload and a loss of situational awareness.

In a similar vein, a formal workload study by Hamilton, Bierbaum and McAnulty (1994), predicted that workload would generally be reduced as pilots went from the traditional cockpit of the AH-64A to the glass cockpit of the AH-64D. However, unstructured interviews conducted with AH-64D pilots suggest that there is perceived to be higher overall workload in the glass cockpit aircraft than in the traditional cockpit design model (the AH-64A).

The current measures of pilot perceptions have been anecdotal and thereby had limited utility. A formal investigation of pilots' attitudes toward the cockpit design of their aircraft was necessary. Practically, it is unfeasible to objectively measure all aspects of crew interaction with the visual displays and instruments. It is unfeasible because there are too many factors involved in flying a helicopter. To try to gain a handle on the areas that may be most important with regard to interacting with the visual displays/instruments, we elected to query active pilots. These pilots have first-hand knowledge of what type of effort is required to interact with the different cockpit designs.

This paper reports findings from a study that investigated U.S. Army aviator attitudes regarding workload, safety, crew coordination, situational awareness, and training as a function of crewstation design. This paper compares the glass cockpit models of the AH-64D and OH-58D aircraft (Figure 1). Two companion papers report the attitudes of AH-64 and OH-58 pilots toward the traditional and glass versions of their aircraft (Francis et al., 2002; Rash et al., in press).

The motivation for comparing these two glass cockpit aircraft was to identify common benefits and problems with glass cockpit designs from the pilot's point of view. The AH-64D and OH-58D are very different aircraft with different years of service, different mission profiles, and different aircraft frames, engines, and capabilities. Given these differences, it may seem that any comparison of pilot opinions across the aircraft would be a process of comparing apples and oranges. However, we felt such comparisons could be made because the survey used to judge opinions (see below) was restricted to a discussion of the role of visual displays and instruments.

Thus, the comparison across aircraft is a comparison of pilot attitudes about how the visual displays and instruments within their aircraft contribute to various aspects of flying the aircraft.

### Research procedures and methodology

#### Experimental design

The design for this study consisted of a combined quantitative and subjective (respondent comments) approach. The unit of analysis was Army aviators. A survey questionnaire was utilized as the instrument for data collection. Participation was limited to AH-64 and OH-58 aviators. Questionnaire items were developed primarily to investigate the attitudes of pilots toward the visual displays and instruments in their aircraft.

#### Population

The populations of interest were AH-64D and OH-58D rated aviators and aviators in the Aircraft Qualification Course (AQC) for these aircraft. Both Active Duty and National Guard aviators were included. These populations are located at diverse Army posts around the world. High concentrations of these populations exist at Fort Rucker, Alabama (U.S. Army aviation training center), Fort Campbell, Kentucky, and Fort Hood, Texas.

The current estimated populations for U. S. Army rotary-wing aviators indicate that there are 265 AH-64D pilots as well as 662 OH-58D pilots in active duty and National Guard units.

#### Data excluded from the study

Two submitted questionnaires were removed from the study. Their removal was based primarily on level of completeness. An acceptable questionnaire was defined as one in which the respondent provided responses to at least 90% of those questions which were applicable to the respondent's indicated aircraft experience. Specific responses to questions were treated as missing data if these responses fell into one of the following categories: Multiple answer response, no response, illegible response, or irrelevant response. Of the removed questionnaires, one did not report the primary aircraft and the other had only answered questions on the first page.

#### Instrument

The instrument used was a paper questionnaire developed by researchers at the U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL (USAARL). Individual questions were evaluated for validity by USAARL research aviators. A copy of the questionnaire is provided in Appendix A.

The questionnaire consisted of a common set of 8 demographic questions and 31 research questions about the visual displays/instruments in their aircraft. The research questions were organized into six main areas: Workload, safety, crew coordination, situational awareness,

training, and overall opinion. Each area provided one open-ended question where respondents were asked to suggest any changes to the visual displays/instruments.

The questions on workload were designed to cover topics that are generally recognized as contributing to workload (e.g., the National Aeronautics and Space Administration Task Load Index (NASA TLX), Hart and Staveland, 1988). These topics included mental activity, physical activity, performance time, and frustration. Additional questions tried to assess whether the aviator feels the workload levels are manageable and comfortable. The questions did *not* measure workload directly, but instead asked the aviator to provide an opinion about various aspects of interacting with the visual displays/instruments. The responses can be taken as the aviator's attitude about factors that are related to workload.

The questions on safety tried to gauge the aviator's attitude about the aircraft's accident rate and whether the visual displays and instruments have much impact on the aircraft's safety.

The questions on crew coordination were based on the Aircrew Coordination Exportable Training Package Student Guide (Department of Defense, 1992), a training document on crew coordination. This document is part of a course on crew coordination taught to all aviators.

The questions on situational awareness were designed to measure the aviators' attitudes about whether the visual displays and instruments help maintain awareness of the aircraft status and flight environment. Some of the questions are loosely based on the SART technique for measuring situational awareness (Taylor, 1990). However, the questions do *not* try to directly measure situational awareness. The questionnaire was only trying to measure aviators' attitudes about how they think the visual displays and instruments influence situational awareness.

The questions on training focused on three issues. The first issue was how difficult it was to learn to use the visual displays and instruments. The second issue was to rank order the various factors during training and flying of the aircraft according to how much they contributed to learning to use the visual displays/instruments. In conversations, aviators have indicated that learning to use the glass cockpit aircraft required additional experience after formal training. The third issue also was identified by conversations with aviators. Several aviators flying with glass cockpit crewstations stated that after a period of time away from the aircraft, there was a loss of proficiency flying the aircraft, and relearning was required to return to an appropriate level. We asked aviators how much of the loss was related to interaction with the crewstation instruments.

The "overall" questions allowed respondents to indicate their general view of the use of MFDs in rotary-wing aircraft.

In addition to the questions in the six main research areas, two additional areas were to be answered by a subset of the respondents. All aviators who flew glass cockpit aircraft were asked to answer questions about details of the MFD in their aircraft. The first question focused on the physical characteristics of the MFD and visibility of the screen. The second question focused on

the information content of the MFD. The final question focused on the aviator's awareness of what the MFD was doing and how to get information from the MFD.

All aviators who had previously flown a traditional cockpit model of the same aircraft (AH-64A or OH-58A/C) were asked questions about the transition from the traditional to the glass cockpit models. They also were asked to compare the traditional and glass cockpit models across a number of general issues.

### Data collection

Questionnaires were distributed via two mechanisms. The most extensive distribution was accomplished via mailing questionnaires to aviation unit safety officers at aviation posts both within and outside of the continental United States. Safety officers were requested to disseminate the questionnaires at monthly safety briefings. Where possible, the unit safety officers were sent email reminders one month after the initial questionnaire mailing.

The second distribution mechanism was via the annual U.S. Army Forces Command (FORSCOM) Aviation Safety Officers' Conference held in Atlanta, GA, in March 2002. Attendees were briefed on the scope and purpose of this study and were requested to carry additional questionnaires back to their respected units.

Since the data gathered are the result of a voluntary survey rather than a random sample, readers are cautioned about inferring specific findings to the general population. Nevertheless, the demographic data described below seem representative of the population, and we have no knowledge of systemic deviations of our sample from the population.

### Method of analysis

The primary purpose of this study was to look for systematic differences in responses from the aviators who fly the AH-64D and the OH-58D glass cockpit models. Except for demographic data, questionnaire responses were of two types. A majority of the questions were presented using Likert scales that included various forms of replies that measured different levels of satisfaction, agreement, or rank. The remaining questions required hand-written comments of a qualitative nature.

The data for each question were described by reporting the percentages of times pilots gave each response. This information is provided in a bar graph that contrasts the data from the AH-64D and OH-58D pilots. This information describes the attitudes of pilots about the topic of the question. In addition, a Mann-Whitney U-test was used to compare responses from the AH-64D pilots to responses from the OH-58D pilots. The Mann-Whitney test determines whether there is evidence that the two sets of responses come from different populations (i.e., there is a difference in opinions between the AH-64D and OH-58D pilots). The Mann-Whitney test is a non-parametric statistical procedure for judging the statistical significance of differences in the pattern of responses. When there was a statistically significant difference in attitude across the aircraft, the nature of the difference was discussed. Tables with the frequency of responses for each question are given in Appendix A.

### Sample demographics

The Table presents the central tendencies of the sampled data demographics. Note that the number of responses to some questions does not match the total number of respondents because some respondents did not answer some questions.

One noteworthy characteristic of the demographic data was that the sample of OH-58D pilots includes a large number (50) of instructor pilots, while the sample of AH-64D pilots includes a large number of students in the AQC (78). The difference in status is also reflected in the flight hours. The OH-58D pilots have a much larger average (879) in their aircraft than the AH-64D pilots have in their aircraft (74). Additional details of the demographic data are available in Appendix A.

Table.

Summary of demographic information broken down by AH-64D and OH-58D pilots.

	<b>OH-58D</b>	<b>AH-64D</b>
Number of respondents	168	164
Primary position:		
Pilot	N/A	18
co-pilot	N/A	36
AQC	1	61
Mean age	32.2	31.0
Median year graduated IERW	1997	1997
Mean total rotary-wing flight hours	1368	1000
Mean flight hours for:		
OH-58D	879	159
AH-64D	0	74
OH-58A/C	399	166
AH-64A	45	687
Other	433	328
Number respondents who are:		
Instructor pilot	50	17
Line pilot	81	44
Test/maintenance pilot	17	12
AQC	9	78
Other	10	9
Number respondents from:		
Fort Bragg	22	0
Fort Campbell	44	5
Fort Hood	50	52
Fort Rucker	34	68
Other	33	39

Note: IERW stands for initial entry rotary-wing training.

## Data and results

Data were collected for five research areas (i.e., workload, safety, crew coordination, situational awareness, and training), overall opinion of crewstation design approaches, acceptability and use of MFDs, and comparison of traditional and glass cockpit crewstation designs (when appropriate).

Representative responses from the open-ended questions are provided in the discussion. All of the responses to open-ended questions are presented in Appendix B. Occasionally, responses were edited slightly to improve fragmentary responses, verbal lacunae, or misspellings. Places where this occurred are indicated with square brackets [ ].

### Workload

The workload section of the questionnaire consisted of 6 objective questions (#9-14) where each respondent was asked to report on some aspect of crewstation workload using numbers between 1 and 5. One additional question was subjective and open-ended, requesting aviator suggestions on changes to visual displays/instruments that might decrease workload. The following sections summarize the data.

#### Analysis

Figure 2 plots the distribution of responses for each workload question. Each bar plot contains data from both aircraft types for a specific question. The responses of three of the six questions differed significantly between the OH-58D and the AH-64D pilots.

Question 9 asked pilots to characterize the amount of mental activity involved in working with the visual displays/instruments on a scale between "Very little" (coded as 1) and "Very much" (coded as 5). The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=8734.5$ ,  $p=0.000$ ). As Figure 2 indicates, the difference seems to be that the AH-64D pilots tended to have more responses toward the "Very much" end of the scale and fewer responses on the "Very little" end of the scale than the OH-58D pilots. Quantitatively, 57% of the AH-64D pilots responded with the choices on the "Very much" side of the scale, while only 33% of the OH-58D pilots selected those choices.

Question 10 asked pilots to rate the amount of physical activity involved in working with the visual displays/instruments on a scale between "Very little" (coded as 1) or "Very much" (coded as 5). Any differences in ratings across aircraft were not statistically significant ( $U=12942.0$ ,  $p=0.325$ ). As Figure 2 indicates, for both aircraft types the responses tend to be symmetric around the middle of the scale.

Question 11 asked pilots to indicate whether they agreed that the visual displays/instruments minimized the time required to perform tasks. The left side of the scale was marked as "Strongly disagree" (coded as 1) and the right side of the scale was coded as "Strongly agree" (coded as 5).

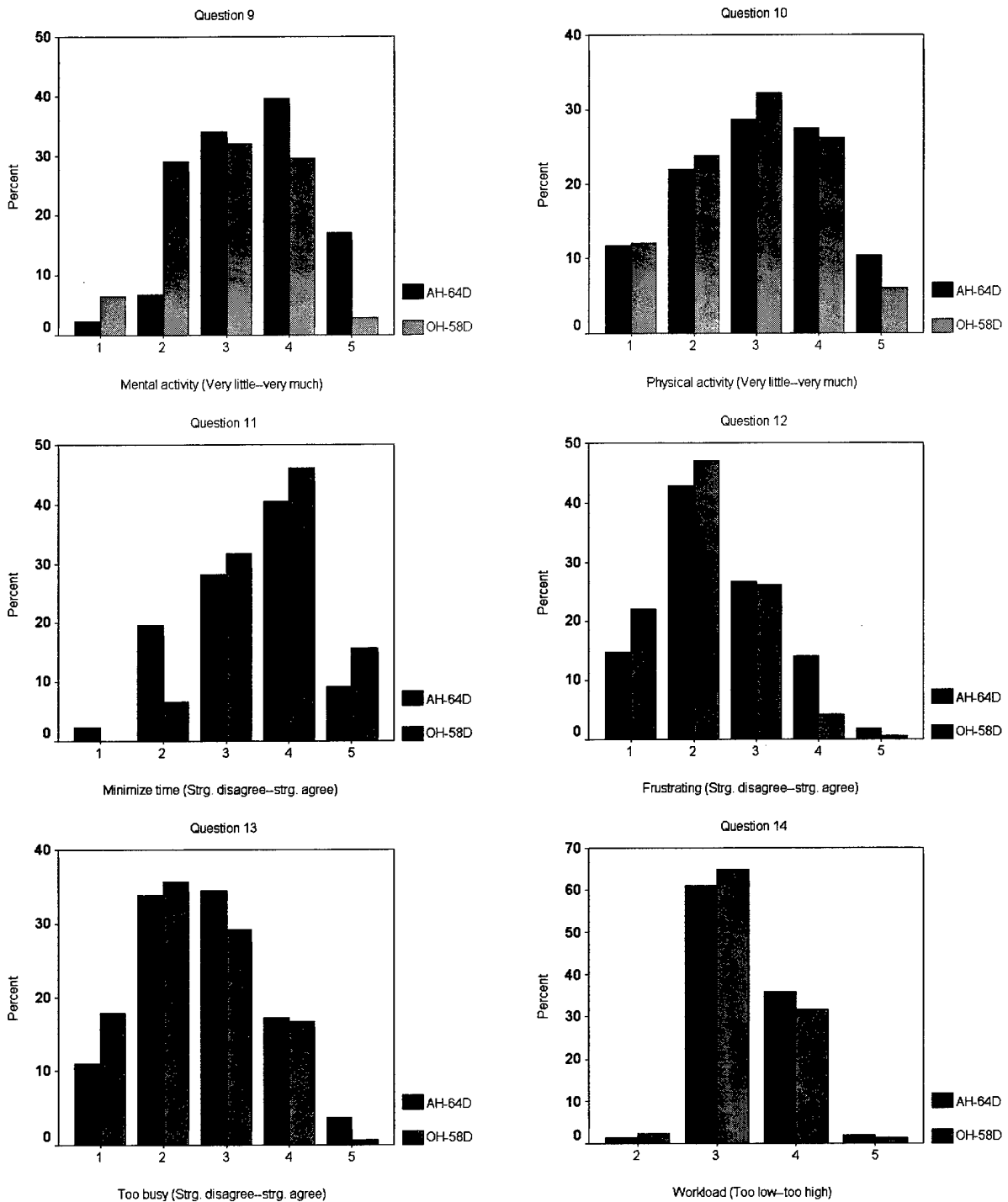


Figure 2. Responses for questions 9-14 on workload. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).



The middle of the scale was coded as "Neutral." The opinions of pilots in different aircraft were dissimilar ( $U=10976.0$ ,  $p=0.001$ ). As Figure 2 indicates, the difference seems to be that the OH-58D pilots had more responses on the "Strongly agree" side of the scale than the AH-64D pilots. Among the OH-58D pilots, 62% chose responses from the agree side of the scale, while 49% of the AH-64D pilots chose such responses.

Question 12 asked pilots to indicate whether they agreed that the design of the visual displays/instruments was frustrating. The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=11418.0$ ,  $p=0.004$ ). As Figure 2 indicates, the difference seems to be that the OH-58D pilots had more responses on the "Strongly disagree" side of the scale than the AH-64D pilots. Among the OH-58D pilots, 69% chose responses from the disagree side of the scale, while 58% of the AH-64D pilots chose such responses.

Question 13 asked pilots to indicate whether they agreed that the design of the visual displays/instruments kept them busier than they needed to be. The difference in opinions of pilots in the OH-58D versus the AH-64D aircraft was marginally significant ( $U=12113.0$ ,  $p=0.058$ ). As Figure 2 indicates, the difference seems to be that the OH-58D pilots had more responses on the "Strongly disagree" side of the scale than the AH-64D pilots. Among the OH-58D, 54% of the responses were on the disagree side of the scale, while 45% of the AH-64D pilots chose such responses.

Question 14 asked pilots to rate whether workload related to the visual displays/instruments is "Too low" (coded as 1), "Too high" (coded as 5), or "About right" (middle). Any differences in ratings across aircraft were not statistically significant ( $U=12966.5$ ,  $p=0.273$ ). As Figure 2 indicates, for both aircraft types, the responses tend to be clustered around the "About right" response or one step toward the "Too high" response. Pilots from both aircraft are much more likely to rate the workload related to the visual displays/instruments as high rather than low.

#### Respondent comments

As this was the first open-ended question, many pilots used it to discuss a variety of topics and suggestions on the visual displays/instruments.

Many OH-58D pilots requested a larger MFD with color. Pilots also requested changes to the MFK (multi function keyboard). Several pilots also complained about the difficulty of retrieving information from the MFD. Finally, several pilots commented that the introduction of additional capabilities tends to increase workload. Representative comments from the OH-58D pilots are:

- We need color screens with higher resolution.
- Make the multifunctional keyboard more accessible and user friendly to both crew members (location and design).
- OH-58D MFD pages and system controls are not very 'intuitive.' They require changing back and forth between pages, remembering where for example, to find a single required item on another page, then return to main page. Left seat is high workload.

- Glass cockpits are great. The problem arises when too many G-whiz capabilities are added which ultimately leads to increased workload.

Other pilots offered some specific recommendations, and these are detailed in Appendix B.

The AH-64D pilots commented on the need for an improvement to the FLIR (forward looking infrared) system and that the ORT (optical relay tube) should be removed and replaced with another MFD. Representative comments from the AH-64D pilots are:

- New FLIR, binocular sights, NVG [night vision goggle] usage should all be considered.
- Get rid of ORT and put in an MPD [multi-purpose display].
- Need a third MPD in front seat of AH-64D. The ORT currently in use is too small of a screen to be easily viewed when on a mission. Also, ORT handles are entirely too "busy." Some of the function buttons should be moved to the third screen bezel.
- With only two displays, I tend to feel restricted as to what information is immediately available while in flight, as compared to what is available.

Several comments also indicated satisfaction with the visual displays/instruments, and other comments addressed fairly specific details of the visual displays/instruments. Many pilots also made comments about the learning process (several pilots commented that as they were in the AQC, they thought their opinions would change later). All of the comments are provided in Appendix B.

### Conclusions

The statistical analysis indicated differences in opinion between the OH-58D and AH-64D pilots. In general, the OH-58D pilots report lower ratings of factors that should contribute to workload. This includes lower ratings of mental activity, higher ratings of the display minimizing the time to retrieve information, and lower frustration ratings. These opinions probably reflect differences in the overall capabilities and responsibilities of the aircraft. The AH-64D is a newer aircraft and it has mission tasks that require more effort from the crew. The differences may also reflect differences in the populations across aircraft. Since many of the AH-64D pilots are in AQC, they are probably not as familiar with the details of working with the visual displays/instruments as the OH-58D pilots. As a result, the difference in opinions might reflect the overall lack of familiarity of the AH-64D pilots with their aircraft.

An important observation is that ratings by pilots of both aircraft tended to be favorable. The ratings overall suggest that pilots of these aircraft find the glass cockpit design conducive to their tasks.

### Safety

The safety section of the questionnaire consisted of 3 objective questions (#16-18), where each respondent was asked to rate some measure of safety on a scale between 1 and 5. One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual

displays/instruments that might improve safety. The following sections summarize the data responses.

### Analysis

Figure 3 plots the distributions of responses for each question dealing with safety. Each bar plot contains data from both aircraft types for a specific question. The responses of one of the three questions differed significantly between the OH-58D and the AH-64D pilots.

Question 16 asked pilots to rate between “Very little” and “Very much,” how much they thought the visual displays/instruments contributed to accidents in their aircraft. Any differences in ratings across aircraft were not statistically significant ( $U=13598.5$ ,  $p=0.991$ ). As Figure 3 indicates, while responses were spread across the rating scale, for both aircraft types, there was a bias for responses among the “Very little” end of the scale.

Question 17 asked pilots to judge whether they thought the accident rate for their aircraft was higher or lower than the fleet average accident rate (9.46). The middle position of the scale was marked as “Same.” The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=8620.0$ ,  $p=0.000$ ). As Figure 3 indicates, the difference was that the OH-58D pilots had many more responses on the “higher” end of the scale and fewer responses on the “Much lower” end of the scale than the AH-64D pilots. Quantitatively, 62% of the OH-58D pilots responded with choices on the higher side of the scale, while 26% of the AH-64D pilots selected those choices.

It is worth noting that the accident rate for the OH-58D and AH-64D models over the years asked in the question (1996-2000) was actually much higher than the fleet average (9.46 per 100,000 hours). For the OH-58D, the accident rate was 20.21 accidents per 100,000 flight hours, while for the AH-64D, the accident rate was 22.44 (Rash et al., 2001). The OH-58D pilots seem to be aware that their accident rate is higher than the fleet average, while the AH-64D pilots are not aware of their aircrafts higher accident rate. In part, this could be because reports of the accident rate of the OH-58 have been discussed recently (Simmons, 2001), while the accident rates of the AH-64 model aircraft have not been as widely discussed.

Question 18 asked pilots to rate between “Very little” and “Very much,” how much they thought the visual displays/instruments could be improved so as to reduce accidents in their aircraft. The opinions of pilots in the OH-58D versus the AH-64D aircraft did not differ ( $U=13018.0$ ,  $p=0.538$ ). As Figure 3 indicates, most responses are at the middle of the rating scale, or one step above or below the middle of the scale.

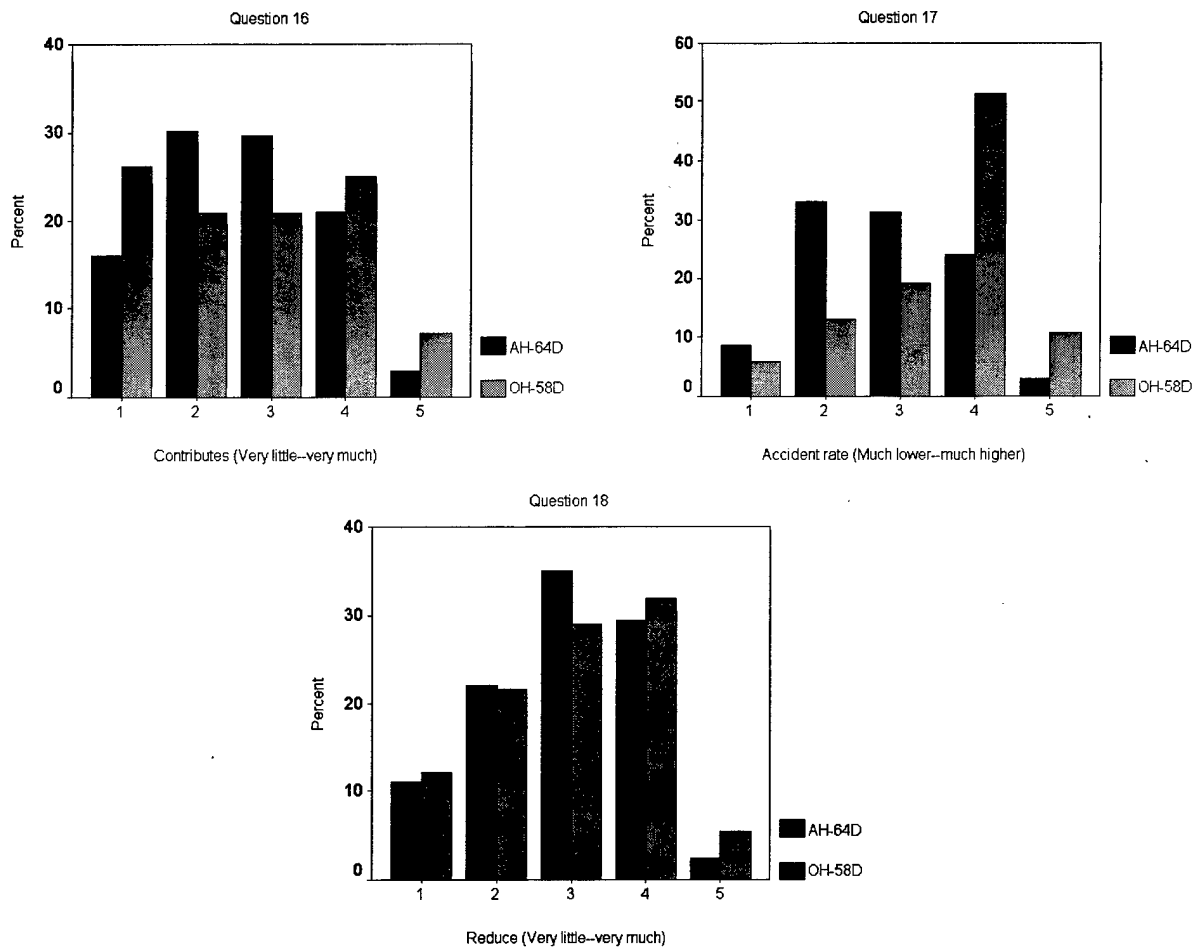


Figure 3. Responses for questions 16-18 on safety. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

#### Respondent comments

Many of the comments on the open-ended safety question were similar to the comments provided after the workload question.

Several OH-58D pilots noted that the MFDs tend to draw the crew members into the aircraft, which might cause accidents. Some pilots asked for simpler MFDs or an ability to remove clutter from the screen. Representative comments of the OH-58D pilots were:

- Our visual display instruments are great. [One] factor that needs to change [is that] pilots bring...too much attention inside due to complicated system sequences and co-pilots' inabilities to perform tasks. Keep it simple.
- One of the side effects of this aircraft displays brings both crew members inside. Unfortunately this display is needed for our mission.
- The aircraft display tends to draw both pilots inside the AC. Decluttering displays could help this.

Other pilots offered some specific recommendations, and these are detailed in Appendix B.

The AH-64D pilots commented on the need for an improvement to the FLIR system, and that the ORT should be removed and replaced with another MFD. In addition, several pilots commented on problems with viewing the MFDs and on a need for more permanent representations of some types of data. Representative comments of the AH-64D pilots were:

- It would be nice to have engine page instruments displayed at all time.
- Eliminate the ORT in AH-64D CPG [copilot/gunner] station and replace with MPD. This would allow CPG to better divide focus inside and outside.
- MPDs and dashboard in backseat are about 1-2" too low. As a longer legged pilot, I cannot use park brake in back seat and can't see all of MPDs in front seat.
- Use analog instruments - a circled compass rose is generally missed. I used to just see 45 and 90 degree tick marks on the HSI (horizontal stabilizer indicator). Now with only a hdg [heading] tape, I have to do the math in my head for traffic pattern work.

Several pilots also commented that the MFDs tended to keep them "inside" the aircraft and that some of the paging procedures could use improvement. All of the comments are provided in Appendix B.

### Conclusions

The analysis suggests that pilots of both aircraft do not consider the current visual displays/instruments in their aircraft to be strongly related to accidents. This was not a particularly surprising result because accidents are rare and are often related to specific circumstances where the role of the visual displays/instruments (if they played any role) would be secondary or tertiary in nature. The only significant differences across aircraft were with regard to knowledge of the accident rate of the aircraft. This likely reflects publication of the accident rates.

### Crew coordination

The crew coordination section of the questionnaire consisted of 5 objective questions (#20-24), where each respondent was asked to indicate whether they "Strongly disagree" (coded as 1) or "Strongly agree" (coded as 5) with the question statement. The middle position was marked as "Neutral." One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments that might improve crew coordination. The following sections summarize the data responses.

### Analysis

Figure 4 plots the distributions of responses for each question dealing with crew coordination. Each bar plot contains data from both aircraft types for a specific question. None of the differences in responses were statistically significant, although two questions were marginally significant.

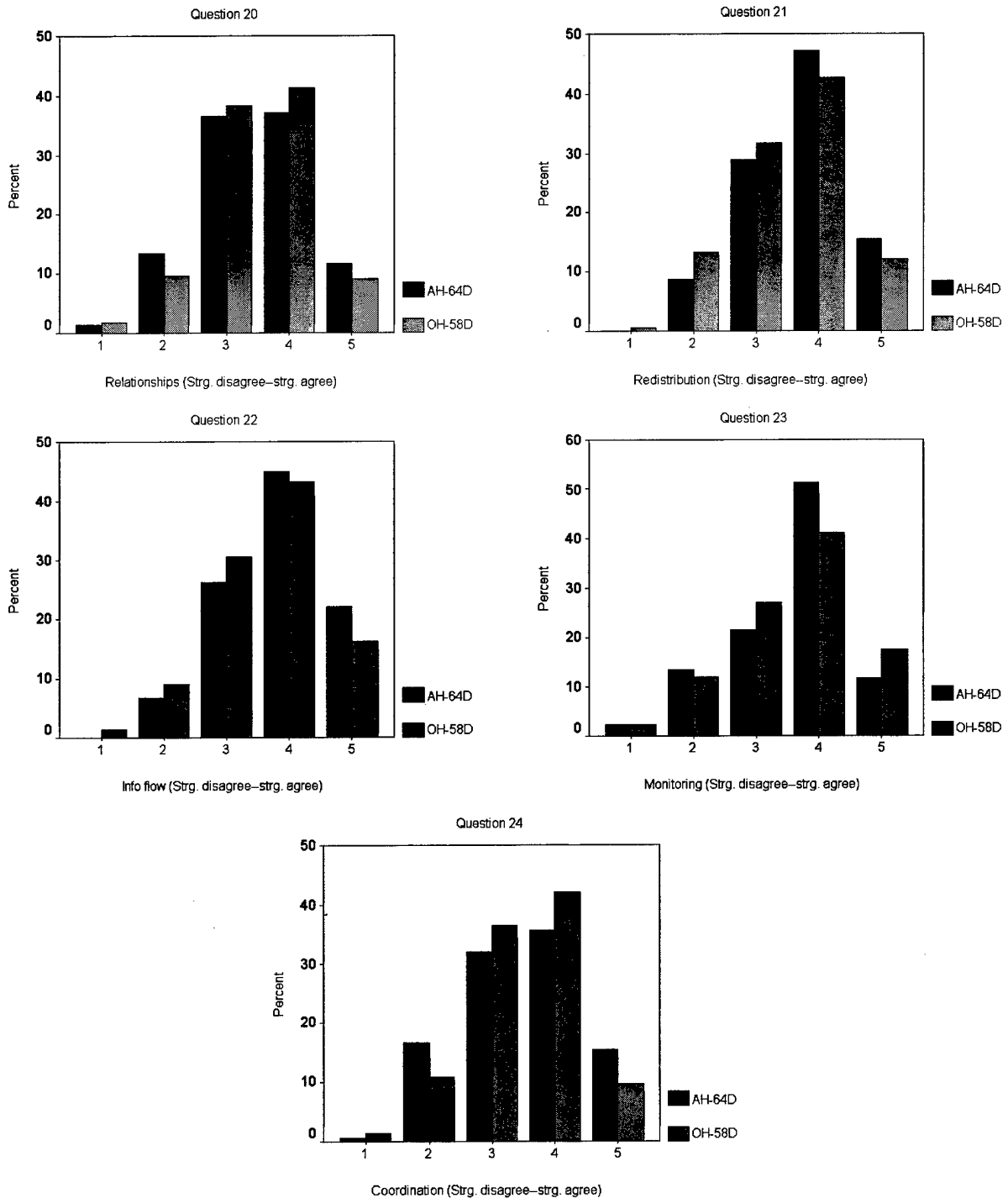


Figure 4. Responses for questions 20-24 on crew coordination. Responses for the OH-58D pilots are in red (dark gray) and responses for the AH-64D pilots are in green (light gray).

Question 20 asked pilots if they agreed that the visual displays/instruments contributed to positive crew relationships. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13503.0$ ,  $p=0.815$ ). As Figure 4 indicates, both pilot groups were neutral or tended to agree with this statement.

Question 21 asked pilots if they agreed that the visual displays/instruments promoted redistribution of crewmember responsibilities. The difference in opinions of pilots in the OH-58D versus the AH-64D aircraft was marginally significant ( $U=12216.0$ ,  $p=0.086$ ). As Figure 4 indicates, the OH-58D pilots were a little less likely to agree than the AH-64D pilots. Nevertheless, both types of pilots were largely on the "agree" side of the scale. Among the OH-58D, 55% of the responses were on the agree side of the scale, while 62% of the AH-64D pilots chose such responses.

Question 22 asked pilots if they agreed that the visual displays/instruments supported free flow of information among crewmembers. The difference in opinions of pilots in the OH-58D versus the AH-64D aircraft was marginally significant ( $U=12234.0$ ,  $p=0.074$ ). As Figure 4 indicates, the OH-58D pilots were a little less likely to agree than the AH-64D pilots. Nevertheless, both types of pilots were largely on the "agree" side of the scale. Among the OH-58D, 59% of the responses were on the agree side of the scale, while 62% of the AH-64D pilots chose such responses.

Question 23 asked pilots if they agreed that the visual displays/instruments promoted cross-monitoring of actions and decisions. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13535.0$ ,  $p=0.846$ ). As Figure 4 shows, both sets of pilots were largely on the "agree" side of the scale.

Question 24 asked pilots if they agreed that the visual displays/instruments promoted good crew coordination. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13594.0$ ,  $p=0.984$ ). As Figure 4 shows, both sets of pilots were at the middle of the scale or were one step toward the "agree" side of the scale.

#### Respondent comments

OH-58D pilots commented that the side-by-side cockpits in the OH-58D aid crew coordination substantially. A common complaint was that crew members often look at what each other is doing on an MFD and as a result, both crew members are focused inside the aircraft. Representative comments of the OH-58D pilots were:

- I would like to be able to see what left seater is typing as they are typing...
- We need new software so that the MFD can show multiple screens at the same time. Too often the right seater is looking over at the left seater's screen and vice versa.
- Actually, the MFDs have a tendency to cause crews to over coordinate and bring their focus inside the cockpit.
- Too many times crew members look across the cockpit to access info on the other crew member's MFD. Again, who is flying the aircraft?

Other pilots offered some specific recommendations, and these are detailed in Appendix B.

Many AH-64D pilots reported that an ability to see what the other crew member was looking at on the MFD would help improve crew coordination. Another common comment was that the impetus for good crew coordination was on the crewmembers and not related to the instruments. On the other hand, several pilots commented that the visual displays/instruments in the AH-64D made crew coordination more important than ever because different crew members could do very different things at the same time. Representative comments of the AH-64D pilots were:

- Small window stating what MPD pages are up in the other cockpit.
- Crew coordination is made more difficult because the front seat pilot must devote much time to setting up the battlefield properly, the pilot in the back seat does not see changes as they are happening.
- The designs do not promote crew coordination. The crew members must initiate crew coordination.
- Change indication of the page displayed and functions selected by one crew member when the same page is viewed by opposite crewmember. This would help avoid continually selecting the same function by both crew members at the same time.

All of the comments are provided in Appendix B.

### Conclusions

Generally, the analysis suggests that pilots of both aircraft believed the visual displays/instruments contribute positively to crew coordination. There was a slight indication that the AH-64D pilots felt more strongly about this than the OH-58D pilots, but this difference was not significant. In contrast to the quantitative data, many of the written responses from the AH-64D pilots indicated concerns about crew coordination with the glass cockpit design. Several pilots commented that since each crew member could do so many different tasks, it was easy to lose track of what the other person was doing. This may be because in the AH-64D, the pilot and co-pilot cannot see each other. Likewise, many of the OH-58D pilots complained that they spent too much effort insuring crew coordination and this distracted them from other tasks. This combination of findings suggests that while the glass cockpit design have many properties that promote good crew coordination, there may be room for additional improvement.

### Situational awareness

The situational awareness section of the questionnaire consisted of 6 objective questions (#26-31). In the first five questions the respondents were asked to indicate whether they "Strongly disagree" (coded as 1) or "Strongly agree" (coded as 5) with the question statement. The middle position was marked as "Neutral." The last objective question took a different format, as described below. One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments that might improve situation awareness. The following sections summarize the data responses.



## Analysis

Figure 5 plots the distributions of responses for each question dealing with situational awareness. Each bar plot contains data from both aircraft types for a specific question. The responses of only one of the six questions differed significantly between the OH-58D and the AH-64D pilots.

Question 26 asked pilots if they agreed that the visual displays/instruments helped maintain awareness of the aircraft relative to the flight environment. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13206.0$ ,  $p=0.485$ ). As Figure 5 indicates, both pilot groups tended to agree with this statement.

Question 27 asked pilots if they agreed that the visual displays/instruments promoted an appropriate allocation of time spent inside and outside the aircraft. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13663.5$ ,  $p=0.894$ ). As Figure 5 indicates, both sets of pilots had responses that were spread across the middle three choices of the scale.

Question 28 asked pilots if they agreed that the visual displays/instruments allowed access to all the information that was needed. The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=11784.0$ ,  $p=0.014$ ). As Figure 5 indicates, pilots from both aircraft tended to agree with this statement, but the AH-64D pilots agreed more strongly than the OH-58D pilots. Among the AH-64D pilots, 81% of the responses were on the agree side of the scale, while 76% of the OH-58D pilots chose such responses.

Question 29 asked pilots if they agreed that the visual displays/instruments allowed them to get the information they need within an appropriate amount of time. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=13063.0$ ,  $p=0.435$ ). As Figure 5 indicates, the responses of pilots from both aircraft were largely on the "agree" side of the scale.

Question 30 asked pilots if they agreed that the visual displays/instruments allows them to think-ahead of the aircraft. The opinions of pilots in the OH-58D versus the AH-64D aircraft were not dissimilar ( $U=12832.0$ ,  $p=0.244$ ). As Figure 5 indicates, pilots from both aircraft had a bias for the "agree" side of the scale.

Question 31 asked pilots to report how much confidence they placed in the accuracy of the information shown in the visual displays/instruments. The scale was marked by "Low" (coded as 1) to "High" (coded as 5) with "Medium" (coded as 3) in the middle of the scale. The opinions of pilots in different aircraft were not different ( $U=13058.0$ ,  $p=0.429$ ). As Figure 5 indicates, for both groups, the reports were almost all in the medium to high range.

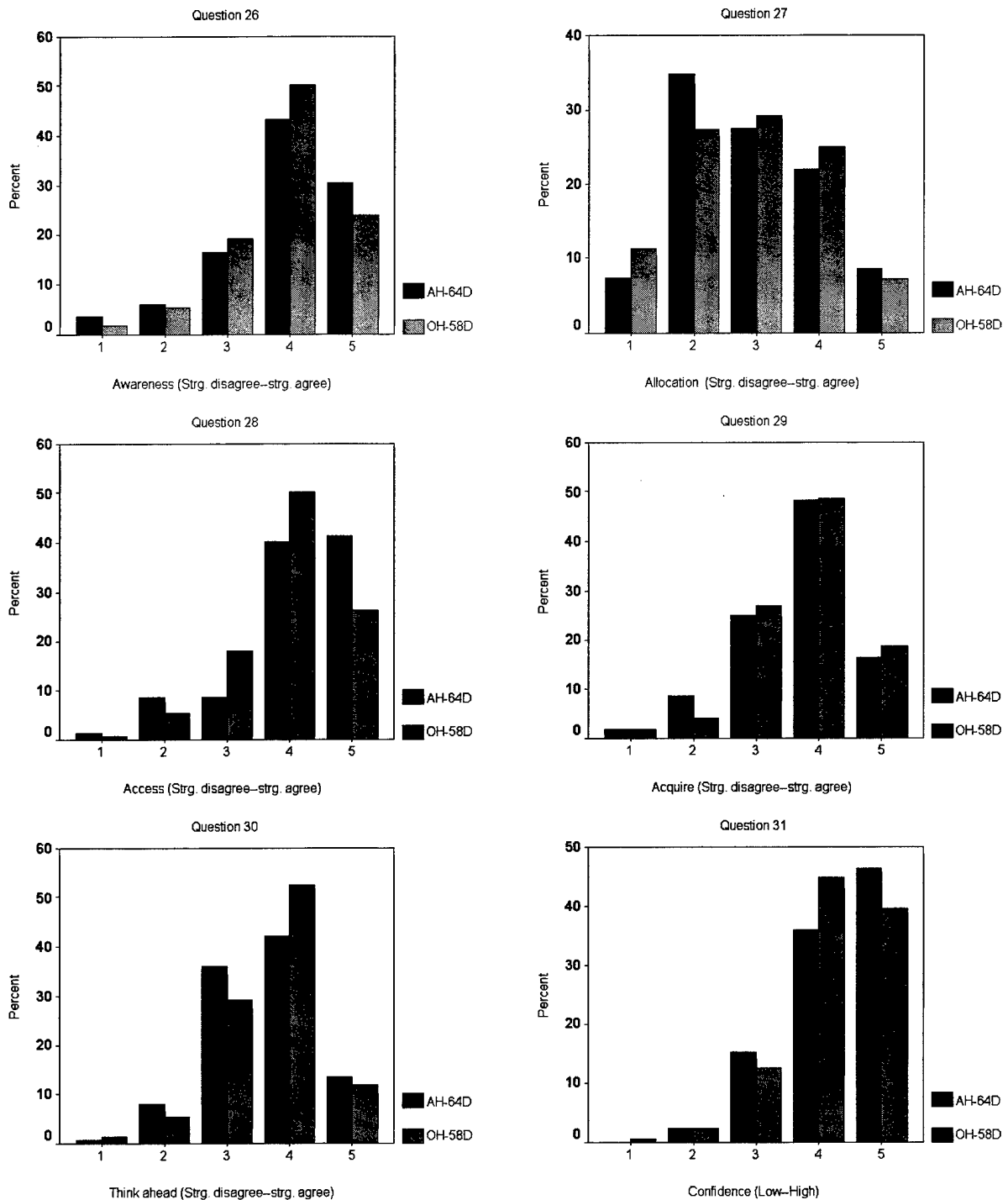


Figure 5. Responses for questions 26-31 on situational awareness. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

### Respondent comments

Several OH-58D pilots requested a moving map display. Representative comments of the OH-58D pilots were:

- Moving map display would improve situational awareness.
- Add moving map display with weather radar improved non-corruptible GPS.
- Changes need to be made for weapon fire pages. So both pilots don't have to be in the cockpit at the same time.

All of the comments are detailed in Appendix B.

Many AH-64D pilots requested a moving map. Other comments also noted that the MFDs tended to make the pilot focus inside the aircraft and that the paging system often required too many button pushes. Representative comments of the AH-64D pilots were:

- Too many menus/screens. Actions that used to take only the push of a button now take longer since we are forced to navigate through multiple "pages."
- Seems both crew members can get sucked into the MPDs and nobody looking outside. "SA" [situational awareness] training can counter this.
- MPDs promote more time inside the cockpit. In my 1-6 hr flight yesterday, I was probably outside for 0.2.
- Moving map underlay with elevation data, real-time emitter download from an external source with LDS information displayed.

All of the comments are provided in Appendix B.

### Conclusions

The analysis indicates that pilots flying the AH-64D and the OH-58D generally believe the visual displays/instruments in their aircraft contribute to good situational awareness. One exception was for the allocation of time inside and outside the aircraft. Here a large percentage of respondents felt the visual displays/instruments did not contribute to a good balance of time inside and outside the aircraft. This issue was also mentioned in the written comments. These beliefs were approximately the same across both sets of pilots.

### Training

The training section of the questionnaire consisted of 3 objective questions (#33-35). One additional question was subjective and open-ended, requesting aviator suggestions on changes to the visual displays/instruments or the AQC training that might improve learning to work with the visual displays/instruments. The following sections summarize the data responses.

## Analysis

Figure 6 plots the distributions of responses for questions 33 and 35 that deal with training. Each bar plot contains data from both aircraft types for a specific question. Figure 7 shows responses for question 34, which was in a different format.

Question 33 asked pilots to rate the difficulty of learning to perform tasks with the visual displays/instruments. The scale ran from "Very easy" (coded as 1) to "Very difficult" (coded as 5), with "About right" anchoring the middle of the scale. The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=10499.5$ ,  $p=0.000$ ). As Figure 6 indicates, both pilot groups tended to believe the learning was "About right" or one step toward the "difficult" side of the scale. The difference in rankings was due to the AH-64D pilots having more responses on the "Very difficult" end of the scale than the OH-58D pilots. Among the AH-64D pilots, 45% of the responses were on the difficult side of the scale, while 30% of the OH-58D pilots chose such responses.

Question 34 asked pilots to rank order the relative importance of factors that might influence their learning to use the visual displays/instruments with 1 indicating the most important, 2 the second most important, and so on. Participants were to leave blank any components they felt did not apply. Figure 7 shows the mean rankings of various training components. The properties of many of these components are self-evident, however a few may need additional description. The computer component refers to various training programs that are available to pilots to practice interacting with the computers in the aircraft. The conversation during AQC and conversation after AQC components refer to discussions pilots might have amongst themselves about how to use the aircraft. The graph is broken down to allow comparison of the mean rankings generated by the OH-58D and AH-64D pilots. The mean rankings are similar across aircraft type. Flight time and simulator time were listed as the most important components (with different ordering) for each aircraft type. Likewise, conversations during and after AQC were listed as the least important components for each aircraft type. However, there were differences as well. A Mann-Whitney test for each of the components found significant differences in the distribution of rankings for the role of the classroom ( $U=9919.5$ ,  $p=0.025$ ), the computer ( $U=7660.5$ ,  $p=0.00$ ), the simulator ( $U=5856.0$ ,  $p=0.000$ ), training flights ( $U=10940.0$ ,  $p=0.004$ ), operational flights ( $U=6073.0$ ,  $p=0.000$ ), and conversations after AQC ( $U=5259.5$ ,  $p=0.000$ ). Differences were not statistically significant for mock-up ( $U=7372.0$ ,  $p=0.343$ ), and conversations during AQC ( $U=10378.5$ ,  $p=0.488$ ).

Question 35 asked pilots how much of a proficiency drop (due to absence from the aircraft) might be due to lack of practice with the visual displays/instruments. The scale ran from "Very little" (coded as a 1) to "Very much" (coded as a 5). The opinions of pilots in the OH-58D versus the AH-64D aircraft were dissimilar ( $U=11051.5$ ,  $p=0.003$ ). As Figure 6 indicates, responses from both sets of pilots were largely on the "Very much" side of the scale. However, the AH-64D pilots had more such responses. Among the AH-64D pilots, 76% of the responses were on the very much side of the scale, while 60% of the OH-58D pilots chose such responses.

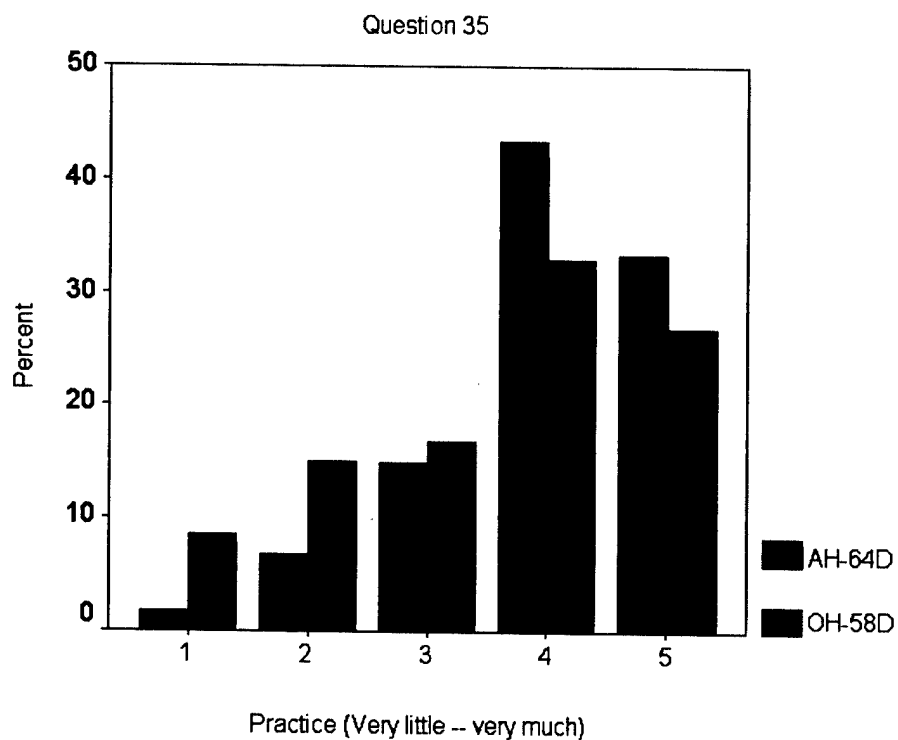
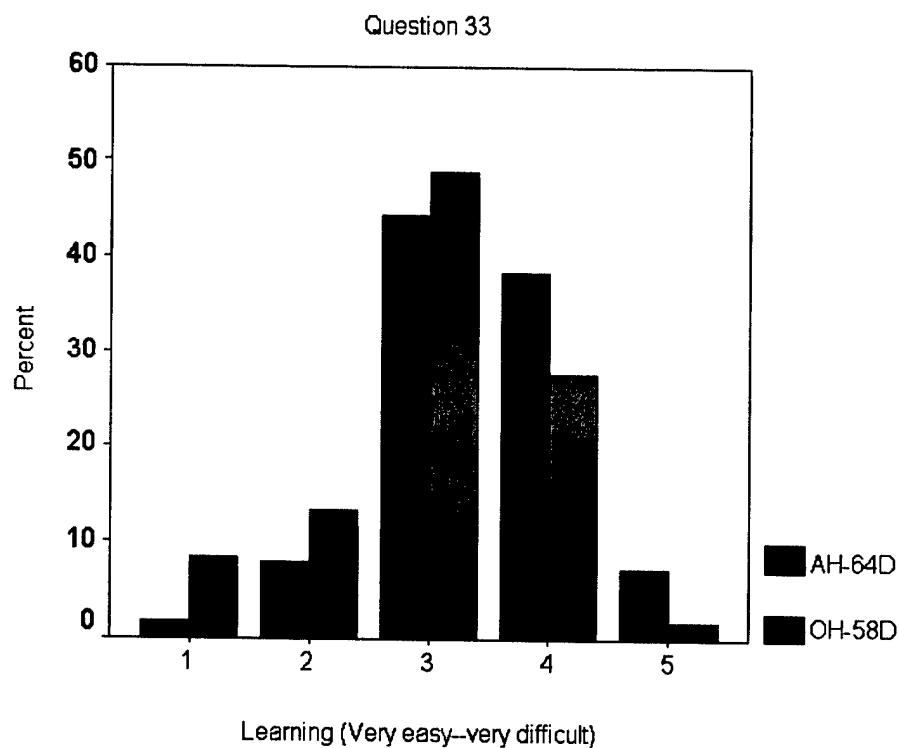


Figure 6. Responses for questions 33 and 35 on training. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

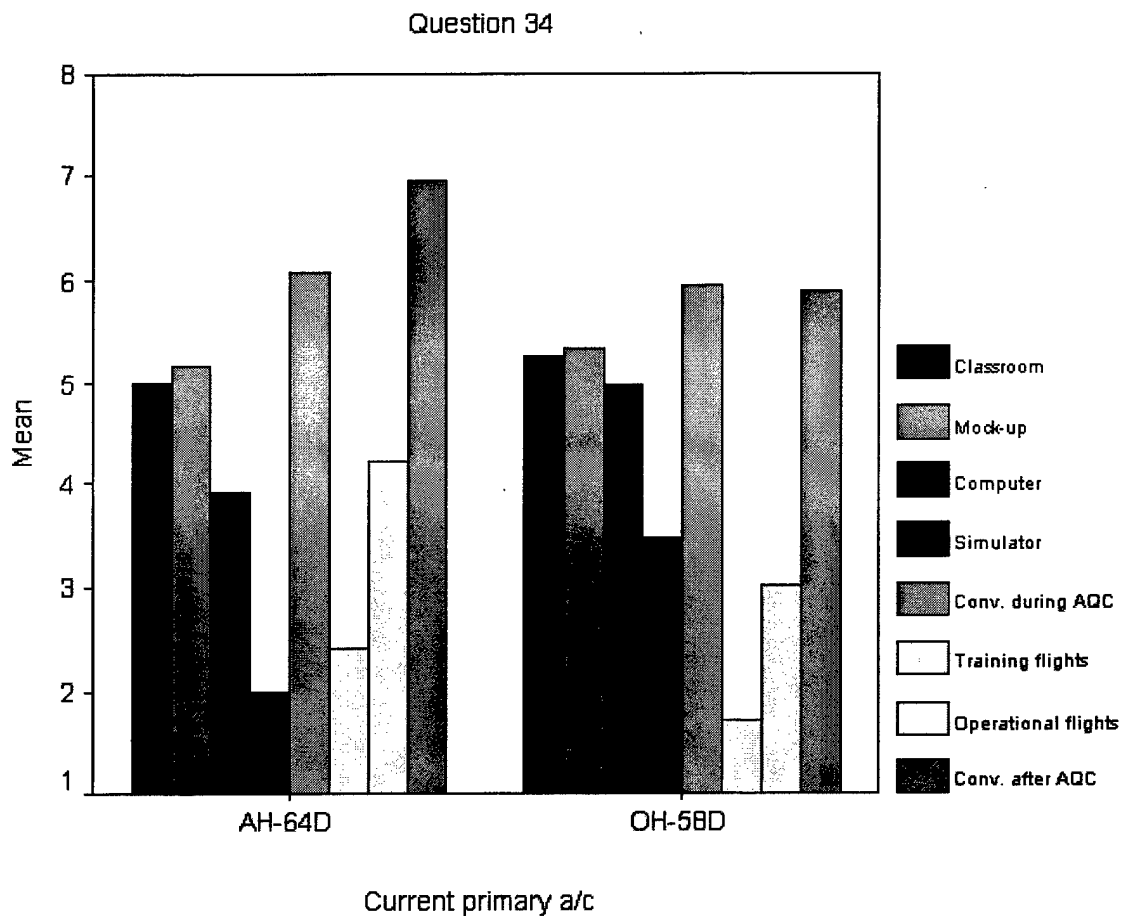


Figure 7. Responses for question 34 regarding the importance of various factors on learning to use the visual displays/instruments.

#### Respondent comments

The OH-58D pilots suggested having more flight time in the aircraft, a motion simulator, and more time with up-to-date computer software. Representative comments of the OH-58D pilots were:

- More training flight time.
- There is no substitute for flight hours.
- Right now the AQC students are learning with CPT's [cockpit procedural trainer] that are a software version behind the current software at the flight line.
- Keep training software as up to date as the software in the aircraft.
- Full motion visual simulator.

All of the comments are detailed in Appendix B.

The AH-64D comments asked for an accurate computer simulator or emulator. Representative comments of the AH-64D pilots were:

- We badly need an updated emulator that will work reliably on newer computers, and much greater access to the LCTs [Longbow crew trainer].
- Need a TSTT [TAD-selected task trainer] type device to practice all MPD ops which include grip and ORT buttons/switches.
- Have an MPD computer program in the learning center. Create a Longbow TSTT. Have more LCT time, get rid of supplemental course.
- Better, more accurate home computer emulators, or something in the way of a C-WEPT [Cockpit weapons emergency training procedure trainer] type device that students can use without having an IP [instructor pilot] there.
- Need to have a mock up for blind cockpit procedures. Split LCT (SIM) periods so they are not back to back to allow discussion. Increase flight line flights to 2.0 [hours] instead of 1.4 [hours] to allow more interactions of tasks in the A/C [aircraft].

All of the comments are provided in Appendix B.

### Conclusions

The overall pattern of responses for pilots in each aircraft was quite similar. However, the OH-58D pilots had better ratings for the ease of learning to use their visual displays/instruments compared to the AH-64D pilots. Likewise, more AH-64D pilots than OH-58D pilots felt that working with the visual displays/instruments was likely to contribute to a drop in proficiency after an absence from the aircraft.

The most significant difference across training components is the role of the simulator across aircraft. The AH-64D pilots ranked this as the most important component, while the OH-58D pilots ranked it as the third most important component.

### Overall

One final set of questions asked pilots to comment on the introduction of MFDs in rotary-wing aircraft. The scale ran from "A bad idea" (coded as 1) to "A good idea" (coded as 5), with "Neutral" marking the middle of the scale. In addition, an option of "No opinion" (coded as 6) was available. The following sections summarize the data responses.

### Analysis

Figure 8 plots the distributions of responses for question 37. The differences in ratings across aircraft were statistically significant ( $U=11857.5$ ,  $p=0.007$ ). Most pilots in both groups believe the introduction of MFDs into rotary-wing aircraft is a good idea. This tendency was stronger among the OH-58D pilots than the AH-64D pilots. Among the OH-58D pilots, 96% of the

responses were on the “good idea” side of the scale, while 90% of the AH-64D pilots chose such responses. Not a single pilot chose the extreme that the introduction of MFDs was a bad idea.

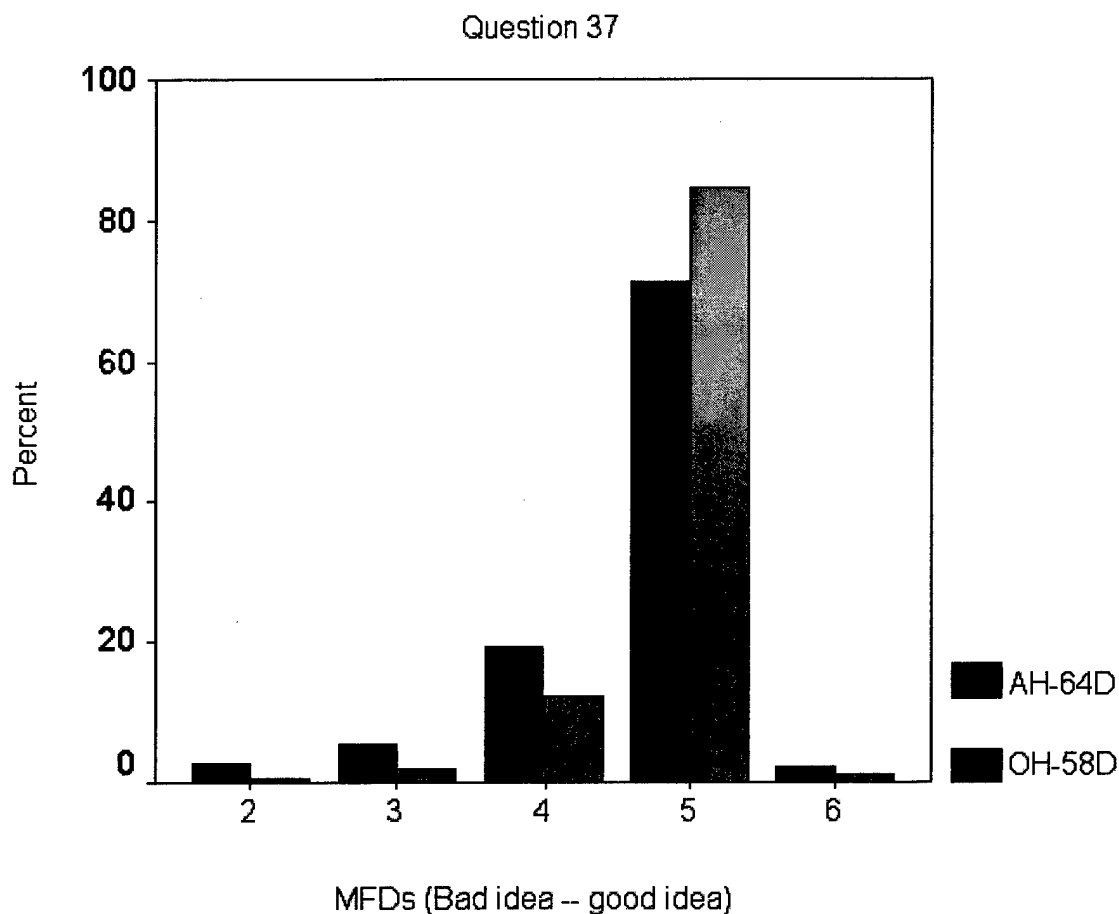


Figure 8. Responses for question 37 on overall inclusion of MFDs. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray). A response of 6 indicates no opinion.

#### Respondent comments

There were no comments from any of the pilots. This probably reflects the position of this question in the survey. After answering several other questions in some depth, pilots did not feel it necessary to comment on anything else.

#### Conclusions

The responses to this question were some of the most focused on the entire questionnaire. There is no question that pilots in both aircraft look favorably upon the use of MFDs in the Army's rotary-wing aircraft.



## Multifunction display details

Previous investigations of aircraft accident rates suggested higher accident rates for glass cockpit crewstation designs (Rash et al., 2001). Previous research (e.g., Francis and Reardon, 1997) and discussions with some pilots suggested that interacting with the MFDs could be a difficult and confusing task. Therefore, an additional set of questions was added to the survey asking pilots for their opinion about various aspects of the MFDs in their aircraft. By comparing these responses across glass cockpit aircraft, we hoped to identify aspects of glass cockpit design that are viewed favorably or unfavorably by pilots.

### Analysis

Figure 9 plots the distributions of responses for question 39, which asked the pilots to rate various physical features of the MFDs on a scale that ran from "Poor" (coded as 1) to "Excellent" (coded as 5). The questions asked pilots to rate the following features: number of buttons, size of buttons, spacing of buttons, range of brightness and contrast controls, daytime screen visibility, nighttime screen visibility, screen visibility in the presence of internal reflections, location of MFDs for visibility, and location of MFDs for reach. The distributions of responses were never skewed to the "Poor" side of the scale. Almost all pilots rated the physical features of the MFDs in the middle or toward the "Excellent" end of the scale.

Statistical tests explored if there were differences between the ratings of pilots from different aircraft. The tests found differences for: size of buttons ( $U=10510.5$ ,  $p=0.035$ ), range of brightness and contrast controls ( $U=8205.0$ ,  $p=0.000$ ), daytime screen visibility ( $U=7115.5$ ,  $p=0.000$ ), screen visibility in the presence of internal reflections ( $U=7677.0$ ,  $p=0.000$ ), and location of MFDs for visibility ( $U=10550.0$ ,  $p=0.047$ ). With one exception (regarding the location of MFDs for visibility), the AH-64D pilots tended to rate their display more on the excellent side of the scale than the OH-58D pilots. The difference in ratings on the question of the spacing of the buttons was marginally significant ( $U=10615.5$ ,  $p=0.061$ ), with the AH-64D pilots having slightly more responses on the excellent side of the scale than the OH-58D pilots. No significant differences were found for ratings of: the number of buttons ( $U=11976.0$ ,  $p=0.879$ ), nighttime screen visibility ( $U=10944.0$ ,  $p=0.590$ ), and location of the MFDs for reach ( $U=10858.0$ ,  $p=0.116$ ).

Figure 10 plots the distributions of responses for question 40, which asked the pilots to rate various aspects of the information content provided by the MFDs on a scale that ran from "Poor" (coded as 1) to "Excellent" (coded as 5). The questions asked pilots to rate the following features: overall amount of information available, organization of information across pages, ease of obtaining needed information, layout of information on the screen, and customizability of information presentation. The distributions were biased toward favorable responses. Most pilots rated the properties of information content of the MFDs in the middle or toward the "Excellent" end of the scale. One exception was for the OH-58D pilots with regard to customizability of the information presentation. For the OH-58D pilots, more responses to this question were on the "Poor" side of the scale than on the "Excellent" side of the scale.

Statistical tests explored if there were differences between the ratings of pilots from different aircraft. The tests found a difference only for customizability of information presentation ( $U=8191.5$ ,  $p=0.000$ ). The AH-64D pilots have a much more favorable opinion of this aspect of their visual displays/instruments than the OH-58D pilots. No significant differences were found for the ratings of: the overall amount of information available ( $U=11035.5$ ,  $p=0.182$ ), organization of information across pages ( $U=10980.0$ ,  $p=0.136$ ), ease of obtaining needed information ( $U=11431.0$ ,  $p=0.328$ ), and layout of information on the screen ( $U=11535.5$ ,  $p=0.386$ ).

Figure 11 plots the distributions of responses for question 41, which asked the pilots to rate the frequency of events related to accessing information from the MFD on a scale that ran from "Never" (coded as 1) to "Always" (coded as 5). Four types of events were rated: "Without looking at the MFD, you know what page you are currently on," "When you know what information you want, you *immediately* know which page you need," "When you know which page you need, you *immediately* know how to get to that page," and "When the MFD displays the page you need, you *immediately* know where the desired information is located on the screen." For the AH-64D pilots, the responses for these questions were more toward the middle than for the other questions about MFD properties. Even so, more answers were on the "Always" side of the scale than on the "Never" side of the scale, indicating that pilots believe they have good knowledge about how to interact with the MFD. This trend was much stronger for the OH-58D pilots, where almost all responses were on the "Always" side of the scale.

Statistical tests were run to compare differences in ratings for the OH-58D and AH-64D pilots. Statistical significance was found for every question, indicating that the OH-58D pilots were more likely to give ratings on the "Always" side of the scale than the AH-64D pilots. Details of the tests were: "Without looking at the MFD, you know what page you are currently on" ( $U=8274.5$ ,  $p=0.000$ ), "When you know what information you want, you *immediately* know which page you need" ( $U=6296.5$ ,  $p=0.000$ ), "When you know which page you need, you *immediately* know how to get to that page" ( $U=7018.5$ ,  $p=0.000$ ), and "When the MFD displays the page you need, you *immediately* know where the desired information is located on the screen" ( $U=7637.0$ ,  $p=0.000$ ).

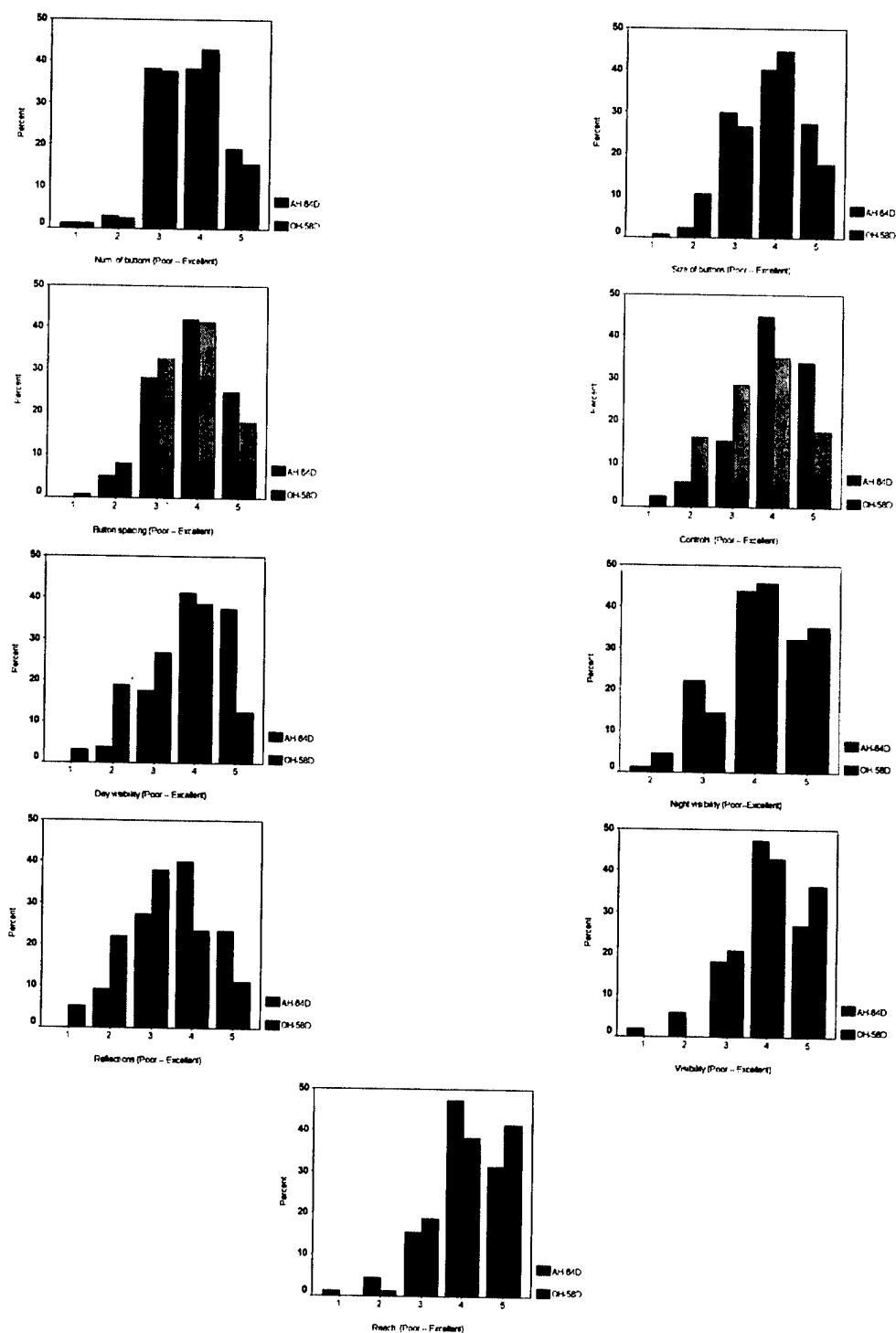


Figure 9. Responses to question 39 about the physical features of MFDs. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

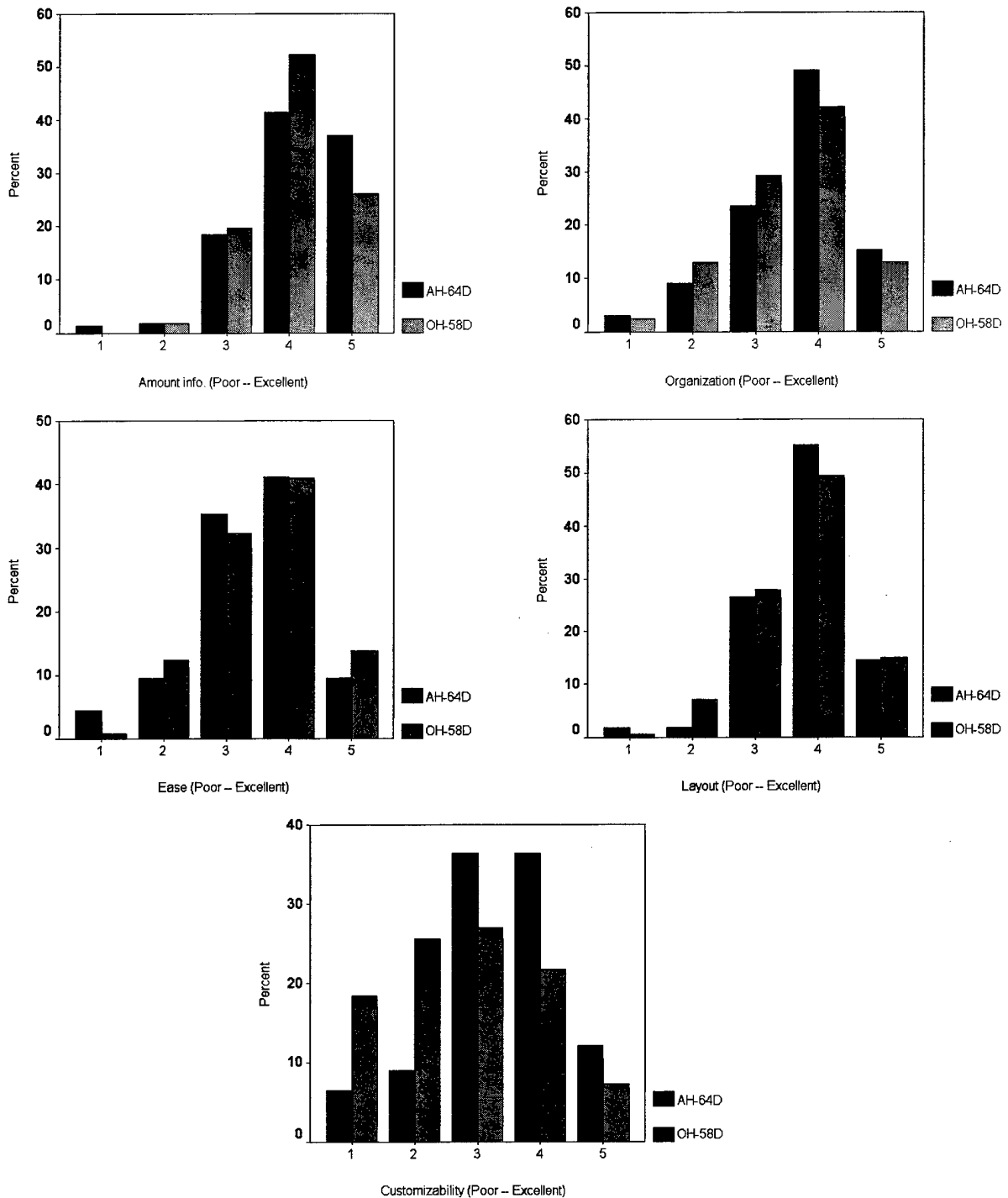


Figure 10. Responses to question 40 about the information content provided by the MFD.  
Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

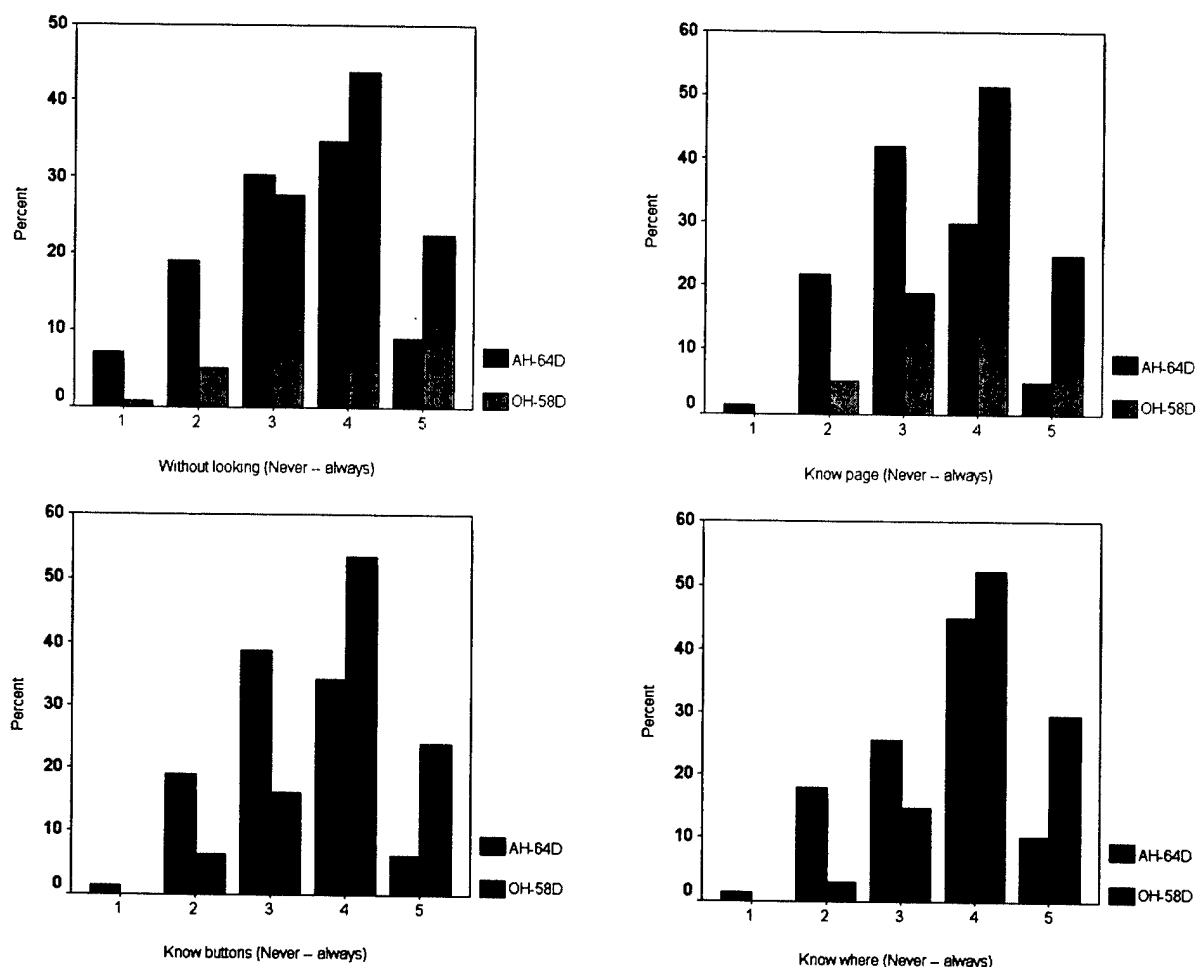


Figure 11. Responses to question 41 about working with the MFD. Responses for the OH-58D pilots are in green (light gray) and responses for the AH-64D pilots are in red (dark gray).

### Respondent comments

There were no comments from any of the pilots. This probably reflects the position of this question in the survey. After answering several other questions in some depth, pilots did not feel it necessary to comment on anything else.

### Conclusions

The data suggest quite favorable opinions of the pilots on the design characteristics of the MFDs. The ratings were quite high for both the physical features of the MFDs and the information content of the MFDs. For the AH-64D pilots, the ratings were not quite as high for

questions about working with the MFDs, but the ratings were still skewed to a desirable end of the scale. For the OH-58D pilots, the ratings were high for questions about working with the MFDs.

The main difference among the ratings of the AH-64D and OH-58D pilots involved working with the MFDs. The OH-58D pilots gave higher ratings for their ability to know where to find and how to retrieve information from the MFDs. This difference could reflect at least two characteristics. First, the AH-64D has more features and capabilities than the OH-58D, and this difference is reflected in the complexity of the MFDs. With fewer pages and levels, the OH-58D pilots have a better chance of memorizing the entire structure of the OH-58D MFD and thereby giving high ratings for these questions. Second, the OH-58D has been flown for more years than the AH-64D. Pilots of the OH-58D generally have more flight hours in their aircraft (879 on average) than pilots of the AH-64D (74 on average). The low number for the AH-64D pilots in this survey is because most of the pilots were in the AQC for the AH-64D at the time they took this survey. This difference in flight hours indicates that the OH-58D pilots have more experience working with their MFD, and this difference would be expected to lead to higher ratings on these questions.

#### Transition from traditional to glass cockpit model

The final set of questions (43-44) asked pilots of the AH-64D and OH-58D who had transitioned from the traditional cockpit model (AH-64A and OH-58A/C) to rate the transition process and to compare the traditional and glass cockpit aircraft across a variety of factors. We felt that these pilots might have a special viewpoint on the potential positives and negatives of each aircraft and could give an impression of the aircraft's overall acceptability.

#### Analysis

Figure 12 plots the distributions of responses for question 43, which asked the pilots to rate whether the transition between models with regard to the visual displays/instruments was "Very difficult" (coded as 1) or "Very easy" (coded as 5). For the AH-64D pilots, there was a bias for responses to be on the difficult side of the scale, while for the OH-58D pilots, there was bias for responses to be on the easy side of the scale. A statistical test shows that this difference is significant ( $U=5878.0$ ,  $p=0.000$ ).

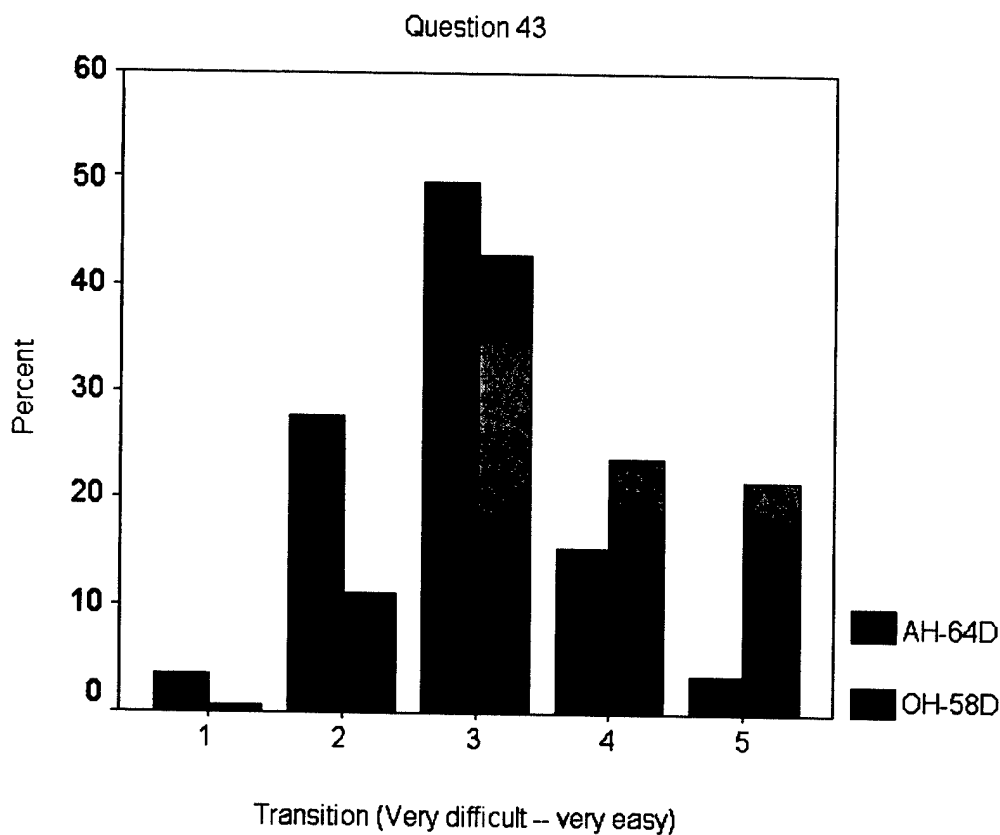


Figure 12. Responses to question 43 about the transition from the A-model to the D-model. Only the AH-64D and OH-58D pilots who transitioned from an A/C-model were asked this question.

Figure 13 plots the distributions of responses for question 44, which asked the pilots to choose between the traditional and glass cockpit aircraft in response to a sequence of questions. The rating scale ran from "Definitely traditional" (coded as 1) to "Definitely glass" (coded as 5).

For the AH-64D pilots, responses were fairly balanced between the traditional and glass cockpit models for questions "Which model of aircraft is safer?" and "Which model of aircraft has lower workloads?" Responses among the AH-64D pilots were clearly biased toward the traditional cockpit design for the question "Which model of aircraft is easier to learn?" Nearly 80% of the responses were in the middle of the scale or on the "traditional" side of the scale. All of the remaining responses from the AH-64D pilots were clearly biased toward the glass cockpit design. This includes questions on "Which model of aircraft would you prefer to fly?," "Which model of aircraft promotes better crew coordination?," "Which model of aircraft promotes better awareness of the aircraft in the flight environment?," "Which model of aircraft promotes better awareness of the aircraft's status?," and "Which model of aircraft better allows you to perform your missions?" The results here are unambiguous. Pilots who have transitioned from the AH-64A to the AH-64D believe the visual displays/instruments in the AH-64D result in a better aircraft.

The same pattern of results is found for the responses of the OH-58D pilots, with one exception. On the question regarding whether the traditional or glass cockpit version of the OH-58 aircraft was safer, the OH-58D pilots who had made the transition from one to the other felt that the OH-58D aircraft was safer. This is a surprising result. Earlier in the survey (question 17), the OH-58D pilots correctly noted that their aircraft had an accident rate above the fleet average. Apparently, the pilots believe that the OH-58A/C aircraft has an even higher accident rate. However, the accident rate for the OH-58A/C aircraft (6.29 per 100,000 flight hours) was much lower than the accident rate for the OH-58D (20.21) over the time period the question covered.

Statistical tests were used to identify differences in responses across the OH-58D and the AH-64D pilots. Differences were found to be statistically significant for the ratings of which aircraft was safer ( $U=6849.5$ ,  $p=0.001$ ), the pilot would prefer to fly ( $U=68888.5$ ,  $p=0.000$ ), and better allows you to perform your missions ( $U=7407.5$ ,  $p=0.025$ ). In all of these cases, the OH-58D pilots had more responses on the "Definitely glass" side of the scale than the AH-64D pilots.

Any differences in ratings were not statistically significant for questions on which aircraft had lower workload ( $U=8857.5$ ,  $p=0.847$ ), was easier to learn ( $U=8074.5$ ,  $p=0.207$ ), promoted good crew coordination ( $U=7663.0$ ,  $p=0.122$ ), promoted awareness of the aircraft in the flight environment ( $U=8671.5$ ,  $p=0.771$ ), and promoted awareness of the aircraft status ( $U=7968.5$ ,  $p=0.120$ ).

#### Respondent comments

Many OH-58D pilots repeated comments that had been made before. Several pilots mentioned the importance of training to use the MFDs. Representative comments of the OH-58D pilots were:

- Again, flight time is the most important element. Perhaps a multi-ship tactical mission in the AQC could help make students aware of the need to have systems operations down cold.
- Easier software. Define user [requirements] before writing code. Send software personnel to units to go over by item what users would like. Also, voice integration would be easy to do as input and screening mechanism [is] already in place.

All of the comments are provided in Appendix B.



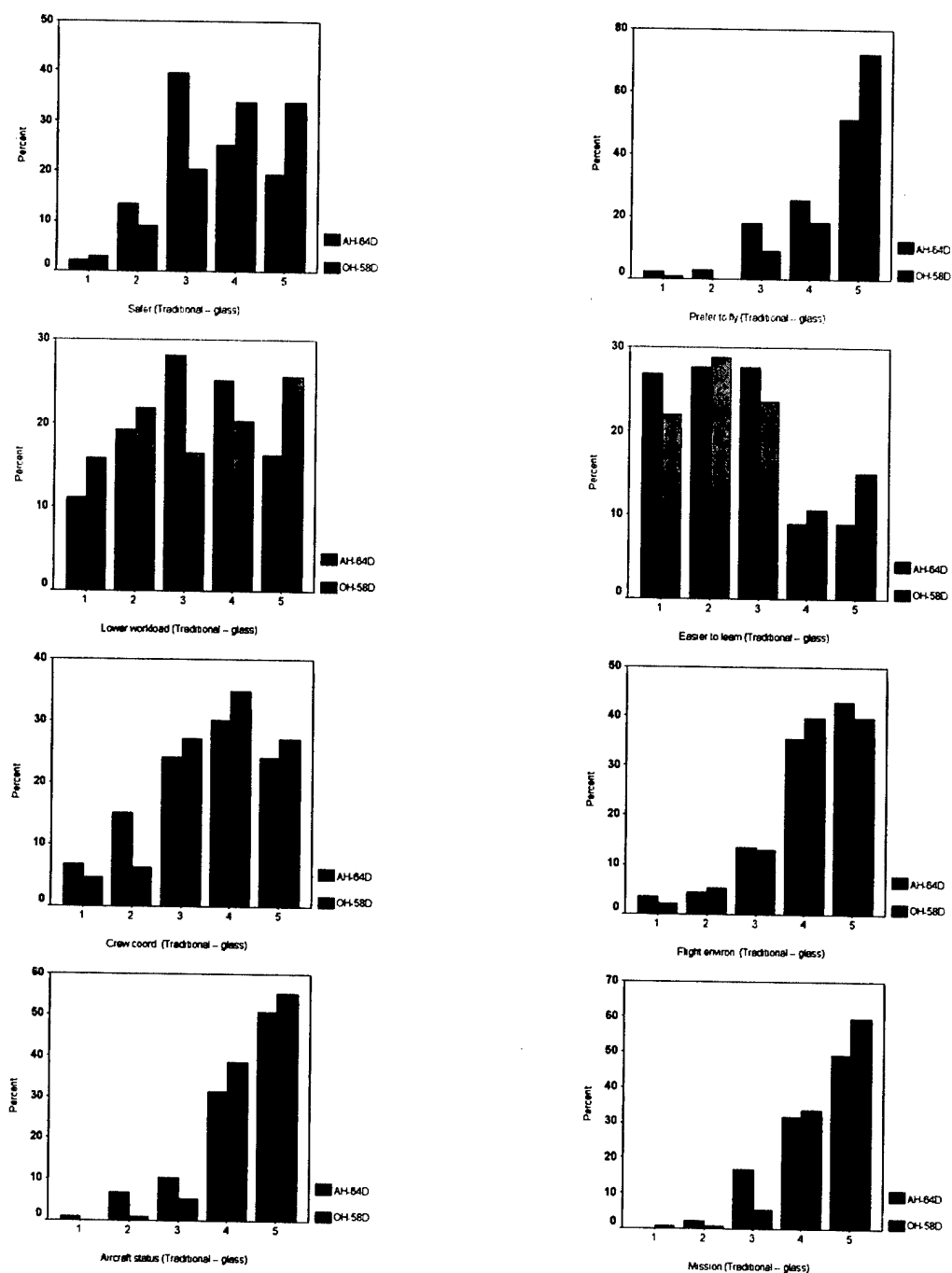


Figure 13. Responses from question 44 comparing the aircraft with different crewstation designs. Only the AH-64D and AH-58D pilots who transitioned from an A/C-model were asked this question.

Comments generally asked for additional time and opportunities for training. Many respondents also suggested that if the survey was repeated a year from now (when they have gone through more training) the answers would be very different. Representative comments of the AH-64D pilots were:

- More MPD training on the hierarchy of how the pages flow. If you know how to get to a page quickly, the MPD tells you what to do there.
- Should have backup instruments in front seat. More training should be available, more flight hours.
- Repetition is the key to success. The more times you perform a given task, the easier it becomes.
- Let me take this survey one year from now. Answers will be different because of higher experience level.
- We are very new to the AH-64D, our interaction with it and the various systems is what is completely new to us. After flying and some experience in the cockpit. Push-in buttons and learning how to crew coordinate actions and employing the machine.

All of the comments are provided in Appendix B.

### Conclusions

The pilot's responses strongly favor the glass cockpit aircraft. The only question where the traditional aircraft had an advantage was with regard to learning to use the visual displays/instruments. Among those pilots who have transitioned from the traditional to the glass cockpit version of the AH-64 and OH-58 aircraft, the pilots' preference is clearly for the glass cockpit model.

### Conclusions

This study was motivated by the recent finding (Rash et al., 2001) that some U. S. Army rotary-wing aircraft with glass cockpit crewstation designs have higher accident rates than corresponding aircraft with a traditional crewstation design. As Rash et al. (2001) noted, there might be many reasons for the difference in accident rates. The current study was designed to try to identify factors that may be related to the accident rate data. By asking pilots for their opinion on the visual displays and instruments in their aircraft as they relate to a number of issues, we hoped to identify how the accident rate and the type of cockpit design might be related.

Comparing pilots opinions about the OH-58D and the AH-64D aircraft only indirectly examines any relationship between glass cockpit designs and accident rates. These aircraft both have glass cockpits and they had similar accident rates. Thus, we cannot contrast the accident rates and relate differences to pilot opinions. However, by comparing the pilot opinions for the OH-58D and the AH-64D aircraft, we can examine the overall views of the pilots for two glass cockpit models and identify aspects of glass cockpit designs that pilots like or dislike.

The primary conclusion from the survey is that, regardless of aircraft type, pilots like the glass cockpit design. For almost all questions, the trend among the responses was to rate the glass cockpit design favorably. The exceptions were the questions on training (questions 33, 35, 43, and one of the sub-questions in 44). Thus, a strong conclusion of this report is that pilots like the glass cockpit design.

A second conclusion from the survey is that the opinions of the OH-58D pilots and the AH-64D pilots are quite similar. Even when the differences across pilot opinions were highly significant, the difference was almost always about the magnitude of a common opinion rather than a difference in the type of opinion (e.g., favorable vs. unfavorable). The only exception was for knowledge about getting information from the MFD (question 41). Here the OH-58D pilots reported having an advantage over the AH-64D pilots with regard to knowing how their system worked and how to get needed information. This latter difference was probably due to the large number of AH-64D pilots who were in the AQC for their aircraft. They are in the process of learning how to get information from the MFD, so it is not surprising that their current skills are behind more experienced pilot, with respect to the use of MFDs.

If we take the opinions of the pilots as a good measure of the contribution of the glass cockpit design to the aircraft accident rate, then we must look at those few factors that were not viewed positively. These factors include the difficulty of learning and maintaining proficiency with a glass cockpit design. One of the original motivations for introducing the glass cockpit designs in aircraft was to increase the capabilities of the aircraft. With an increase in capabilities also comes an increase in the responsibilities and activities of the crew. It seems quite reasonable that the increase in responsibilities will make learning to use the aircraft more difficult. Likewise, with a large number of tasks, time away from the aircraft would make it difficult to remember how to execute the commands for every task and thereby cause deterioration in general flight performance. Each of these issues could be related to the accident rate.

While it is believable that difficulties in training and proficiency among the OH-58D and AH-64D pilots might contribute to safety issues, more study is required to make such a causal link. If it exists, we expect the link should be a strong one. We believe this because the pilots clearly approve of many other characteristics of the glass cockpit design. According to the opinions of the pilots in this survey, the glass cockpit design contributes positively to issues on workload, situation awareness, safety, and crew coordination. Moreover, the pilots agree that the glass cockpit designs are a good idea for U. S. Army rotary-wing aircraft.

Despite these strong favorable opinions, the properties of glass cockpit aircraft have not led to a corresponding decrease in the accident rate relative to traditional cockpit models. Indeed, exactly the opposite is found, with the glass cockpit aircraft having a higher accident rate. Some factors must be working against the favorable properties of the glass cockpit aircraft. If the unfavorable properties are related to learning and proficiency, then they must have quite strong effects to counter the beneficial aspects of the glass cockpit design.

### Recommendations

The results of the survey suggest that there may be difficulties in training and maintaining proficiency of use with the glass cockpit design in the AH-64D. Rash et al. (2001) recommended a follow-up study of the accident rate data when sufficient flight hours became available to support firmer statistical conclusions. We reiterate that recommendation and additionally recommend that when the follow-up accident rate data study is carried out, it should look for a link between the frequency of accidents and the likely proficiency level of the pilots involved. Proficiency level would include total flight hours and number of flight hours over the past 90 days. These numbers would be compared to the total flight hours and flight hours over the past 90 days from a random sample of pilots on flights without accidents. One could then compare the flight hour variables across the accident and non-accident groups to see if there is a significant difference.

In addition, we recommend that the U. S. Army improve the computer training programs for the OH-58D and AH-64D. Although some types of programs are currently available, the reports from pilots are that the programs are out of date and/or incomplete versions of what is actually used in the aircraft. If such programs were up to date and available for use on a home computer, a pilot could practice working with the MFDs even while away from the aircraft. This might help maintain proficiency interacting with the visual displays/instruments.

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## Appendix A.

### Questionnaire: A comparison of pilot attitudes toward traditional and glass cockpits in U.S. Army rotary-wing aircraft.

This appendix includes the questions on the questionnaire and a report of the responses to those questions, broken down by pilots in different aircraft. The values in the tables are the number of times each rank was chosen by the pilots. The bar graphs in the main text converted these numbers to percentages.

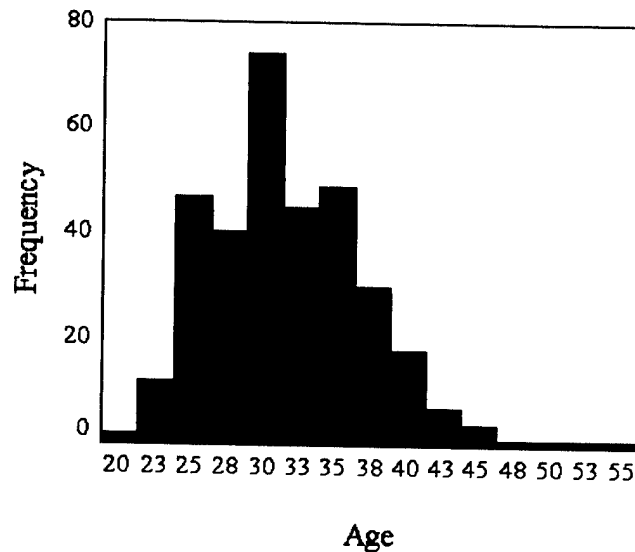
#### Demographics

1) Please indicate your current primary aircraft. If you are currently in transition, identify your transition aircraft (select only one):

- \_\_\_\_\_ OH-58A/C  
\_\_\_\_\_ OH-58D  
\_\_\_\_\_ AH-64A (Please indicate if primarily pilot \_\_\_\_\_, co-pilot/gunner \_\_\_\_\_, AQC \_\_\_\_\_.)  
\_\_\_\_\_ AH-64D (Please indicate if primarily pilot \_\_\_\_\_, co-pilot/gunner \_\_\_\_\_, AQC \_\_\_\_\_.)

	Frequency	Pilot	Co-pilot/gunner	AQC
OH-58D	169			
AH-64D	164	18	36	61

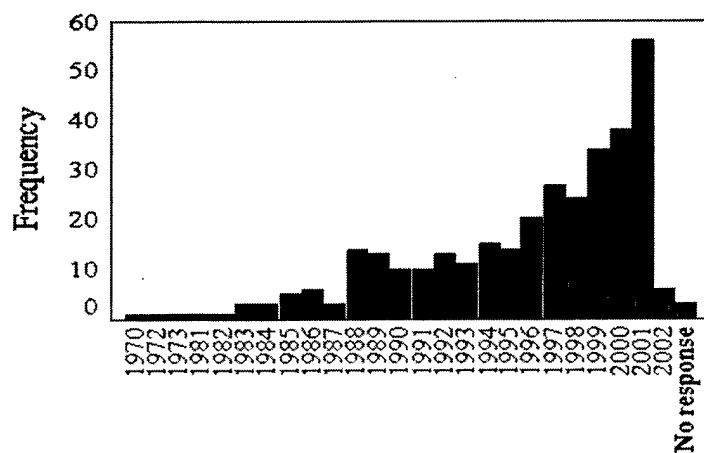
2) Age \_\_\_\_\_



3) Sex (circle one):    male        female

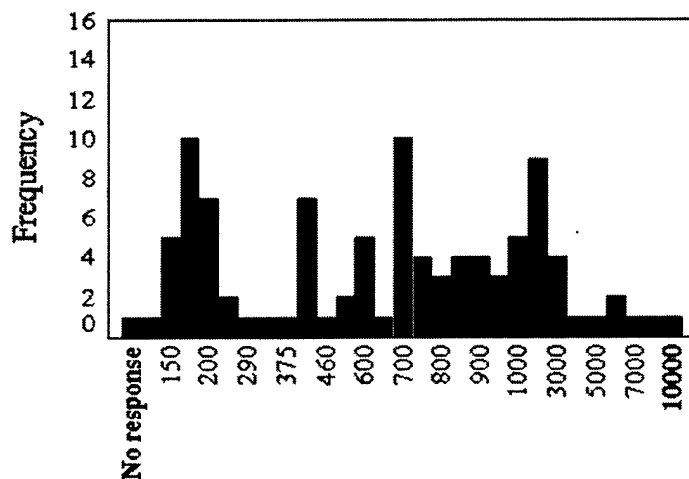
	AH-64D	OH-58D
Male	155	165
Female	9	4

4) Year graduated IERW \_\_\_\_\_

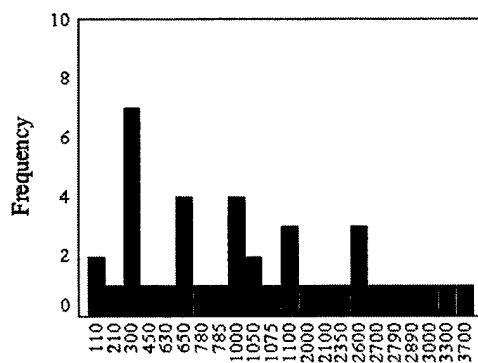


Year graduated IERW

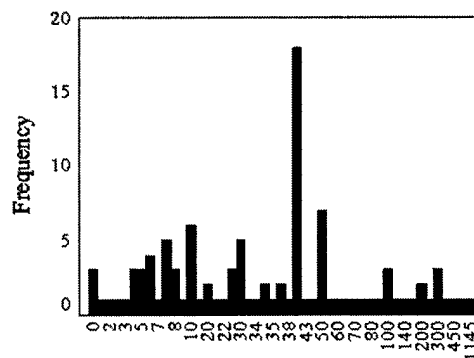
5) Total military rotary-wing aircraft flight hours \_\_\_\_\_



Total military rotary wing flight hours



Total OH-58D flight hours



Total AH-64D flight hours



6) Give aircraft flight hours for any of the following rotary-wing aircraft that you are rated in:

AH-64A     AH-64D     Other   
 OH-58A/C     OH-58D

**AH-64D**

	Minimum	Maximum	Mean	Median	Standard deviation
AH-64A	1	5500	687.25	350	855.073
AH-64D	0	1145	74.17	36	162.138
OH-58A/C	1	3500	166.15	75	371.921
OH-58D	5	350	158.67	70	141.5
Other	1	2000	328.84	150	441.372

**OH-58D**

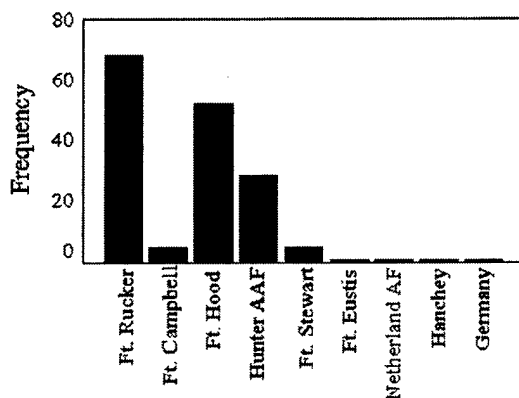
	Minimum	Maximum	Mean	Median	Standard deviation
AH-64A	15	75	45	45	42.426
AH-64D	0	0	0	0	0
OH-58A/C	15	5000	399.36	145	679.351
OH-58D	12	3700	879.09	700	735.090
Other	20	4000	433.16	100	732.065

7) Please indicate your status for your primary aircraft (choose only one):

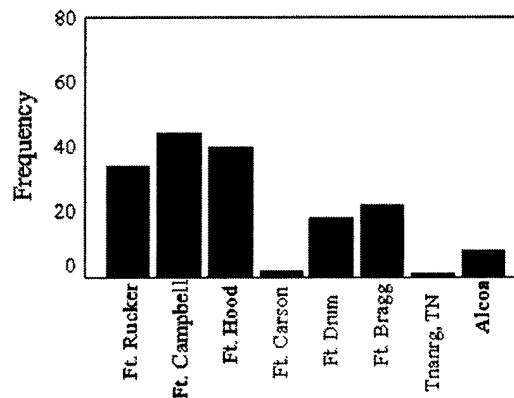
instructor pilot (IP, SIP)     in an AQC     line pilot  
 test/maintenance pilot     Other (please specify)

	Instructor pilot (IP, SIP)	Line pilot	Test/maintenance pilot	In an AQC	Other
OH-58D	50	81	17	9	10
AH-64D	17	44	12	78	9

8) Current unit location (e.g., Fort Hood, Fort Rucker, etc.) \_\_\_\_\_



AH-64D current unit location



OH-58D current unit location

### ***Workload***

**9) Characterize the amount of overall mental activity (e.g., thinking, deciding, calculating, remembering, searching) required to work with the visual displays/instruments.**

1  
Very little

2

3

4

5  
Very much

	1	2	3	4	5
OH-58D	11	49	54	50	5
AH-64D	4	11	56	65	28

**10) Characterize the amount of overall physical activity (e.g., flipping switches, pushing buttons, turning dials) required to work with the visual displays/instruments.**

1  
Very little

2

3

4

5  
Very much

	1	2	3	4	5
OH-58D	20	40	54	44	10
AH-64D	19	36	47	45	17

11) The design of the visual displays/instruments generally minimizes the amount of time required to perform tasks.

1  
Strongly disagree

2

3  
Neutral

4

5  
Strongly agree

	1	2	3	4	5
OH-58D	0	11	53	77	26
AH-64D	4	32	46	66	15

12) The design of the visual displays/instruments is frustrating.

1                      2                      3                      4                      5  
Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	37	79	44	7	1
AH-64D	24	70	44	23	3

13) The design of the visual displays/instruments keeps me busier than I think I need to be.

1                      2                      3                      4                      5  
Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	30	60	49	27	1
AH-64D	18	55	56	28	6

14) The workload in my aircraft, as it relates to using the visual displays/instruments, is:

1                      2                      3                      4                      5  
Too low                      About right                      Too high

	1	2	3	4	5
OH-58D	0	4	109	53	2
AH-64D	0	2	100	59	3

15) Please suggest any changes to the visual displays/instruments that might improve workload levels for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

### Safety

16) How much do you think the design of the visual displays/instruments may contribute to accidents in your aircraft?

1                      2                      3                      4                      5  
Very little                      About right                      Very much

	1	2	3	4	5
OH-58D	44	35	35	42	12
AH-64D	26	49	48	34	5

17) The Army keeps statistics on all Class A, B, and C accidents. Combined across all types of helicopters in the US Army rotary-wing fleet, there was an accident rate of 9.46 accidents for every 100,000 flight hours over the years 1996-2000. Do you think the accident rate of *your* aircraft was higher or lower than the fleet rate?

1                      2                      3                      4                      5  
 Much lower                      Same                      Much higher

	1	2	3	4	5
OH-58D	10	22	32	86	18
AH-64D	14	54	51	39	5

18) How much do you feel that the design of the visual displays/instruments could be improved to reduce the accident rate in your aircraft?

1                      2                      3                      4                      5  
 Very little                      About right                      Very much

	1	2	3	4	5
OH-58D	20	36	48	53	9
AH-64D	18	36	57	48	4

19) Please suggest any changes to the visual displays/instruments that might improve safety in your aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

### Crew coordination

20) The design of the visual displays/instruments contributes to positive crew relationships with open communication.

1                      2                      3                      4                      5  
 Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	3	16	64	69	15
AH-64D	2	22	60	61	19

21) As the mission situation changes, the visual displays/instruments promote effective and efficient redistribution of crewmember responsibilities.

1                      2                      3                      4                      5  
 Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	1	22	53	71	20
AH-64D	0	14	47	77	25

22) The design of the visual displays/instruments supports the free flow of essential mission information among crewmembers.

1                      2                      3                      4                      5  
 Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	2	15	51	72	27
AH-64D	0	11	43	74	36

23) As crew members make actions and decisions, the visual displays/instruments promote cross-monitoring to reduce the likelihood of errors impacting mission performance and safety.

1 Strongly disagree 2 3 Neutral 4 5 Strongly agree

	1	2	3	4	5
OH-58D	4	20	45	69	29
AH-64D	4	22	35	84	19

24) The visual displays/instruments promote good crew coordination.

1 Strongly disagree 2 3 Neutral 4 5 Strongly agree

	1	2	3	4	5
OH-58D	2	18	61	70	16
AH-64D	1	27	52	58	25

25) Please suggest any changes to the visual displays/instruments that might improve crew coordination for this aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

### Situational awareness

26) The visual displays/instruments help me maintain awareness of the aircraft relative to the flight environment.

1 Strongly disagree 2 3 Neutral 4 5 Strongly agree

	1	2	3	4	5
OH-58D	3	9	32	84	40
AH-64D	6	10	27	71	50

27) The visual displays/instruments promote an appropriate allocation of time spent "inside" and "outside" the cockpit.

1 Strongly disagree 2 3 Neutral 4 5 Strongly agree

	1	2	3	4	5
OH-58D	19	46	49	42	12
AH-64D	12	57	45	36	14

28) The visual displays/instruments allow me access to all the information I need.

1                      2                      3                      4                      5  
Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	1	9	30	84	44
AH-64D	2	14	14	66	68

29) The visual displays/instruments allow me to acquire the information I need within an appropriate amount of time.

1                      2                      3                      4                      5  
Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	3	7	45	81	31
AH-64D	3	14	41	79	27

30) The visual displays/instruments help me to "think ahead" of the aircraft.

1                      2                      3                      4                      5  
Strongly disagree                      Neutral                      Strongly agree

	1	2	3	4	5
OH-58D	2	9	49	88	20
AH-64D	1	13	59	69	22

31) How much confidence do you place in the accuracy of the information displayed by your visual displays/instruments ?

1                      2                      3                      4                      5  
Low                      Medium                      High

	1	2	3	4	5
OH-58D	1	4	21	75	66
AH-64D	0	4	25	59	76

32) Please suggest any changes to the visual displays/instruments that might improve situation awareness for this aircraft. Write any comments on the lines below.  
All comments are provided in Appendix B.

Training

33) Learning to perform tasks with the visual displays/instruments was:

1                      2                      3                      4                      5  
Very easy                      About right                      Very difficult

	1	2	3	4	5
OH-58D	14	22	81	46	3
AH-64D	3	13	73	63	12

34) Please rank the following training components involved in learning to use the visual displays/instruments. Give the number 1 to the most important component, the number 2 to the second most important component, and so on. Leave blank any components that do not apply to you.

- \_\_\_\_\_ classroom
- \_\_\_\_\_ mock-up
- \_\_\_\_\_ computer training programs
- \_\_\_\_\_ training simulator
- \_\_\_\_\_ conversation with peers *during* AQC training
- \_\_\_\_\_ training flights
- \_\_\_\_\_ operational flights after training
- \_\_\_\_\_ conversation with peers *after* AQC training

	1	2	3	4	5	6	7	8
Classroom								
OH-58D	5	6	26	18	28	31	20	16
AH-64D	5	9	30	35	29	24	7	16
Mock-up								
OH-58D	12	14	18	26	19	17	18	24
AH-64D	5	7	10	20	19	15	18	13
Computer training programs								
OH-58D	9	10	15	32	29	27	21	10
AH-64D	11	21	38	41	22	7	3	9
Training simulator								
OH-58D	23	35	29	13	11	8	4	9
AH-64D	64	62	26	2	4	1	0	0
Conversation with peers during AQC training								
OH-58D	5	4	8	23	23	27	40	16
AH-64D	2	3	11	23	36	24	37	13
Training flights								
OH-58D	91	39	20	8	6	0	0	0
AH-64D	65	47	24	12	9	4	0	0
Operational flights after training								
OH-58D	23	58	22	20	17	7	3	4
AH-64D	14	16	19	16	14	23	9	3
Conversation with peers after AQC training								
OH-58D	1	3	25	15	17	27	26	31
AH-64D	1	1	0	6	10	20	30	43

35) After not flying for a while, a pilot may notice a temporary drop in proficiency flying the aircraft. How much of this drop in proficiency do you think is the result of a lack of practice with the visual displays/instruments?

1                      2                      3                      4                      5  
Very little                      About right                      Very much

	1	2	3	4	5
OH-58D	14	25	28	55	45
AH-64D	3	11	24	70	54

36) Please suggest any changes to the visual displays/instruments or AQC training that might improve learning to use the visual displays/instruments in your aircraft. Write any comments on the lines below.

All comments are provided in Appendix B.

### Overall

37) In my opinion, the Army's trend to include multifunction displays into rotary-wing aircraft is:

1                      2                      3                      4                      5                      **OR**                      6  
A bad idea                      Neutral                      A good idea                      No opinion

	1	2	3	4	5	6
OH-58D	0	1	3	20	140	2
AH-64D	0	4	9	31	116	3

38) Please use the space below to mention any other opinions you have about the visual displays/instruments or this survey. Write any comments on the lines below.

All comments are provided in Appendix B.

If your current aircraft is not an OH-58D or an AH-64D glass cockpit model and you are not in an AQC for transition to an OH-58D or an AH-64D, you have finished the questionnaire. **Thank you for your time.**

If your current aircraft is an OH-58D or an AH-64D,  
or you are in an AQC for transition to an OH-58D or an  
AH-64D, please answer the questions in the next section.



# MFD details

(ONLY FOR D-MODEL PILOTS OR THOSE WHO ARE IN AN AQC FOR A D-MODEL!)

39) Please rate the acceptability of the following physical features of the MFDs in your aircraft:

	Poor				Excellent
Number of buttons.....	1	2	3	4	5
Size of buttons.....	1	2	3	4	5
Spacing of buttons.....	1	2	3	4	5
Range of brightness and contrast controls.....	1	2	3	4	5
Daytime screen visibility.....	1	2	3	4	5
Nighttime screen visibility .....	1	2	3	4	5
Screen visibility in the presence of internal reflections.....	1	2	3	4	5
Location of MFDs for visibility.....	1	2	3	4	5
Location of MFDs for reach.....	1	2	3	4	5

	1	2	3	4	5
Number of buttons					
OH-58D	2	4	58	66	24
AH-64D	2	5	60	60	30
Size of buttons					
OH-58D	1	16	41	69	27
AH-64D	0	4	47	63	43
Spacing of buttons					
OH-58D	1	12	60	53	27
AH-64D	0	8	44	66	39
Range of brightness and contrast controls					
OH-58D	4	25	44	54	27
AH-64D	0	9	24	70	53
Daytime screen visibility					
OH-58D	5	29	41	59	19
AH-64D	0	6	27	64	58
Nighttime screen visibility					
OH-58D	0	7	2	70	54
AH-64D	0	2	32	65	48
Screen visibility in the presence of internal reflections					
OH-58D	8	34	58	36	17
AH-64D	0	14	42	61	36
Location of MFDs for visibility					
OH-58D	0	0	32	66	56
AH-64D	3	9	28	74	42
Location of MFDs for reach					
OH-58D	0	2	29	59	64
AH-64D	2	7	24	74	49

40) Please rate the acceptability of the information content provided by the MFDs in your aircraft:

	Poor				Excellent
Overall amount of information available.....	1	2	3	4	5
Organization of information across pages (hierarchy) .....	1	2	3	4	5
Ease of obtaining needed information.....	1	2	3	4	5
Layout of information on the screen.....	1	2	3	4	5
Customizability of information presentation.....	1	2	3	4	5

	1	2	3	4	5
Overall amount of information available					
OH-58D	0	3	30	80	40
AH-64D	2	3	29	65	58
Organization of information across pages (hierarchy)					
OH-58D	4	20	45	65	20
AH-64D	5	14	37	77	24
Ease of obtaining needed information					
OH-58D	1	19	50	63	21
AH-64D	7	15	56	65	15
Layout of information on the screen					
OH-58D	1	11	43	76	23
AH-64D	3	3	42	37	23
Customizability of information presentation					
OH-58D	28	39	41	33	11
AH-64D	10	14	57	57	19

41) Please indicate how frequently the following events occur:

	Never	Sometimes			Always
Without looking at the MFD you					
know what page you are currently on. ....	1	2	3	4	5
When you know what information you want, you					
<i>immediately</i> know which page you need. ....	1	2	3	4	5
When you know which page you need, you					
<i>immediately</i> know how to get to that page (e.g.,					
pushing the correct sequence of buttons). ....	1	2	3	4	5
When the MFD displays the page you need, you					
<i>immediately</i> know where the desired					
information is located on the screen.....	1	2	3	4	5

	1	2	3	4	5
Without looking at the MFD you know what page you are currently on					
OH-58D	1	8	43	68	35
AH-64D	11	30	48	55	14
When you know what information you want, you <i>immediately</i> know which page you need					
OH-58D	0	8	29	79	38
AH-64D	2	34	66	47	8
When you know which page you need, you <i>immediately</i> know how to get to that page (e.g., pushing the correct sequence of buttons)					
OH-58D	0	10	25	83	37
AH-64D	2	30	61	54	10
When the MFD displays the page you need, you <i>immediately</i> know where the desired information is located on the screen					
OH-58D	0	5	23	81	46
AH-64D	2	28	40	70	16

42) Please suggest any changes to the MFD that might improve the visual displays/instruments. Write any comments on the lines below.

All comments are provided in Appendix B.

## Appendix B.

### Responses to open ended questions.

Question 15. Please suggest any changes to the visual displays/instruments that might improve workload levels for this aircraft.

#### **OH-58D**

- Color monitors w/changes in color between: i.e., VSI (vertical speed indicator) and airspeed, etc.
- Updated software version.
- Be able to take prep[eration] of WPT (Waypoint) out on the MMS (Mast Mounted Sight) page instead of HSD (Horizontal Situation Display).
- Heads up display.
- Be able to change the pre-point buffer at the MMS page.
- Multi-color display screen.
- Make it color, not green. Have both seats set up the same and add a third control head on a flex cable to run the MMS. Move the master arm and gun control switch to the collective head and get rid of the cargo switch.
- MFK (Multi-Function Keyboard) reacts too slowly. Alphanumeric keys are in alphabetical order (confusing). Should be in computer keyboard format, also buttons are too small.
- Make the multifunctional keyboard more accessible and user friendly to both crewmembers (location and design.)
- Update/upgrade software to default to standard everyday data entries.
- Moving map with terrain relief with colors.
- Additional display unit dedicated to HSD. I know there is not enough room, but we constantly alternate between VSD (Vertical Situation Display), HSD and MMS while in mission profile.
- More user friendly; less pages to accomplish the same task.
- Color display would be nice
- The MFDs (Multi-Function Display) are great. The problem is the amount of info that can be accessed is too great. We have to access to systems that we do not use.
- Have duplicate design of right seat installed in left seat pertaining to radio control. I realize this would overload the cyclic control head somewhat. But hands on control would benefit left seater.
- Less key presses for certain ops [operations]. Be able to load more custom application through amps. Have knee/keypad to type without having to use keypad in center console.
- Do away with digital commo [communications], with secure radio's, voice is still faster than digital.
- Bigger color, moving map.
- Tacan inst[allation] package throughout fleet, not just Ft. Polk. Make getting hellfires off the rails simple again.

- The design of the cockpit keyboard non - qwerty layout placement on console) is extremely difficult to use in flight. Recommend detachable keyboard to be held in CPO's (Co-Pilot Observer) lap.
- Our aircraft is all ergonomic nightmare. Please stop adding equipment that are not useful. That is VIXL (Video Image Cross Link) can't sent to anyone except ourselves and the pictures are not useful.
- Buttons easier to operate, less glare.
- Much of the workload is created by time driven events. The AMDS station is not user friendly and shuts down often. If systems are used properly workload is reduced. IDM is interminant.
- Color MFDs.
- IDM[S] (Improved Data Modem) needs to be improved as far as being user friendly and streamlined.
- Larger TQR numbers and larger rotor RPM numbers color for different items such as torques.
- Color screens as opposed to straight green when incorporating moving map systems.
- Simplify, more common sense.
- MFK awkward position, pilot ICS (Intercommunication System) under collective. Cockpit ergonomics too cramped.
- Moving the multifunction keyboard to a more useable location during flight. Setting up MFK more like a typewriter keyboard instead of alphabetical.
- Color option would be nice.
- Windscreen HUD (Heads-Up-Display).
- Cut down on the amount of useless pages. Create new shortcuts with switches on collective and cyclic.
- The software could be adjusted to make the switchology/display more user friendly. Also MFK is difficult to use, especially at night.
- The MFDs are fine. The MFK is not a good place. How about a kneeboard keyboard that is more user friendly and not in the way of any of the flight controls.
- Standardize the rotor RPM read out between the MPD (Multiparameter Display), VSI, and MFD (i.e., 100=101=102).
- The MFR is poorly placed. It should be placed higher or be detachable for use. As is, it conflicts with the right seater's collective.
- A back or return to the last screen button would be saves button pushes and time spent with concentration focused inside.
- A next and previous waypoint button on VSD and weapon VSD.
- Search light controls on the co-pilot side. AIM-1 laser control on the co-pilot side.
- Illegible rated flight.
- Better integration of singars into the OH-58D. The pages are nested too deep for rapid channel changes when in frequency HOP.
- Enable weapons firing from co-pilot side and MMS controls from pilot side.
- New software changes require too many buttons pushes i.e., FMs to single channel FH, FH master VHF (Very High Frequency) to squelch off.
- I address the answer to use of the displays not the workload caused by the mission.

- Larger MFD with the capability of having more than 1 page displayed at a time.
- We need color screens with higher resolution.
- Would like to have an MFK that has a better location such as new board. The location now is too cumbersome being that it is located too far below the collective.
- The workload incurred is dependent upon which seat the aviator is in. For the right seat pilot the visual display facilitates flying duties particularly the instrumentation. The left seat pilot it is a much heavier workload because he has access to the commo, NAV, MMS and IDM pages. More pop-up menus would help.
- Have computer simulator available (with correct software) for aviators to practice on.
- Larger display.
- Use USI for 58D vertical speed. A back and forward key like internet. Touch screen.
- Number icons on windows above the actual instrument would aide in a more rapid cross check.
- Primary concerns are software errors and total number of tasks. Some tasks require both pilots to be on instrumentation.
- The HSD should be convertible to display HIS data with navigation radio.
- One major item that kept the pilot's attention focused inside has been fixed with CDS-4 (Control and Display Subsystem) software. Weapons symbology in the ADSS.
- Reduce the number of pages required to accomplish a given task.
- Make components smaller and lighter to save weight and space. Color MFDs for better resolution of instruments/maps etc. Simpler programming, too much time wasted on finding correct page, setting up systems, the number of buttons pushes to get a simple maneuver.
- Tasks should be automated i.e., check fuel consumption.
- Keep access pages to a minimum. EX.ATHS (Airborne Target Handover System) on OH-58D takes much longer than a radio call and much easier to make mistakes with.
- RFD or VSD display of Zulu time and mission timers.
- Although the 58D (I) PI flight course allows some interaction without the PI having to release the flight control more would be helpful. Moving the PI ICS to a more viewable spot.
- Flat panel active matrix display- saves weight, easier to maintain easier to view. Unit level adjustable instrument indications. Calibrations should be adjustable by unit level maintenance for discrepancies from VSI/MPD to MFD
- There are some minor functions that could be in more logical places. For example, IFM amplifier initialization should be on a comm page.
- OH-58D MFD pages and system controls are not very 'intuitive'. They require changing back and forth between pages, remembering where for example, to find a single required item on another page, then return to main page. Left seat is high workload.
- Have all the instruments look the same and principally in the same general area.
- To be able to change waypoint on the USD and not have to page off to HSD display to go to next wpt and page back to VSD.
- Project the info on the windscreen or a display screen at eye level.
- As more "nice to have" additions tend to increase pilot workload inside cockpit.
- Glass cockpits are great. The problem arises when too many G-whiz capabilities are added which ultimately leads to increased workload.
- Voice activated page changes.

- Digital spot reports require too many button pushes. Once you target locate you should be able to push one or two buttons to send a spot report or fire mission.
- Color displays and a better sight so you don't have to strain to see what your looking at.

### AH-64D

- Moving map, more fixed action buttons.
- Place MPDs higher on dash so that pilot/CPG spend less time "heads down."
- With only two displays, I tend to feel restricted as to what information is immediately available while in flight, as compared to what is available.
- Change the default location for the flight page to the right UPD because that is the location of the standby instruments.
- Performance planning display- very busy needs to be reorganized.
- Remove the ORT, it is much easier to manage systems with 2 side by side panels as opposed to 2 panels separated by the ORT.
- Provide tail for ADF pointer on flight page.
- Voltage indications in aircraft. Hydraulic indication on up front display standby instrument in the front seat.
- Third MPD in front seat-Remove ORT.
- Great improvement in the glass cockpit of the AH-64.
- Possible put more MPD controls on the collective/cyclic.
- Get rid of ORT in AH64D.
- I have 1.9 hours in the airframe. Probably also has to do with the little experience I have use trackball cursor control rather than present pressure cursor controller.
- Add one more MPD that generally (only) monitors system instruments (you don't have to switch pages that often then).
- They are pretty well designed. All buttons including ORT need backlights.
- More use of cursor ( i.e., being able to use cursor to draw actual layout of power lines for example). Make pages more open ended allowing for more modification of routes, target assignment.
- Not enough experience to comment.
- Leave as is.
- At this point things are more confusing and frustrating due to having a set way of doing things and now trying something new. I am sure things will get easier as I spend more time in the a/c.
- Need a third MPD in front seat of AH-64D. The ORT currently in use is too small of a screen to be easily viewed when on a mission. Also, ORT handles are entirely too "busy." Some of the function buttons should be moved to the third screen bezel.
- Bigger MPDs, more FABs (All top-level MPD pages should have FABs outside the MPD).
- Please provide standby airspeed attitude and altitude analog instruments in both crew stations.
- A true HIS format.
- Move ORT and add third MPD.

- MPDs are great minor corrections in varied terminology are needed I.e., shot at BDA options logic sequencing can be improved for menu items. Overall situation is adequate.
- Emergency procedures should not have to require finding certain pages to turn on or off systems. A hard switch should be available for speedy on/off during emergency situations.
- Standby instruments in both CPG (Co-pilot) and pilot station.
- I think it would be better to survey pilots that have more time in this a/c. This a/c frustrates me now because I'm just learning it. Once I'm more familiar with it my opinion of it will probably change.
- During generator failure (dual) or complete loss of a/c power, there are no indication remaining for Np(Power Turbine Speed), Nr (Rotar Speed), Tq. The triple TAC should be reinstalled as part of the emergency flight instrument package.
- Develop I simple menu page that is arranged like a table of contents/INDEX. Access to a page # through the keyboard unit.
- The basis for my survey is from a students perspective. With time it will make our jobs easier.
- Currently unable to adequately assess cockpit design of the AH-64D. On first indication workload is great but as scan patterns are developed, workload rapidly decreases.
- If they could add the MSL ALT while the transition mode it would be nice.
- Continue to refine ergonomics I.e... move FLT page to right MPO and keep end page on left MPD during any engine/power train emergencies.
- AH64D cockpit is extremely user friendly. Reduces scanning and provides greater attention to be outside A/C.
- A lot of info for two screens.
- Only have 5 hrs in a/c. They need to develop a TSTT for the Longbow; ensuring LCTs are in all posts is very important for hands on practice.
- Customizable screens.
- Most of my high ratings are due to my inexperience in the aircraft and with the glass cockpit. I feel once the initial shock is over it will be a useful tool.
- Get rid of ORT and put in an MPD.
- Put analog FLT instruments in both cockpits. Maintain systems on MPDs.
- Removal of the AH-64D ORT would help front seat workload.
- A line diagram on the weapons page linking "swarm" element would aid in reducing time ready to fire weapon system at designated TGT.
- Not enough time in glass cockpit to make determination.
- If at all possible reduce the level of pages. Make a pure utility main page and would love to have a touch pad instead of a thumb force controller.
- Moving map display. Upgrade TADS/PVVS FLIR.
- Additional analog instruments.
- Put a third MPD in the pilot station.
- Better trainers to maximize hands on.
- Too many menu option per page especially, the top level pages.
- New FLIR, binocular sights, NVG usage should all be considered.
- Not enough time in AQC (supplemental) to be an effective crewmember in first unit after graduation.



- Glass cockpit is great but everything is on only 2 MPDs. So when you have to enable, disable or change something you are taking away an MPD. Add enable switches, eg. TADS, WPNs (Weapon), XPNOR.
- The glass cockpit needs to move closer towards the accepted GUI design principles used in the commercial sector i.e., Mac/Windows.
- Not enough experience in AH-64D to suggest.
- Eventually, I will be proficient in using the system. Right now it is frustrating because everything is new.
- FLR provides many false targets, so improve the FLR accuracy. TADS/PNVS needs upgrading. Map holding patterns on the visual display.
- Digital cockpit makes trend detection more difficult than analog. Needles on instruments moving together. I would not mind digital instruments designed like analog ones. For example the HIS/compass is difficult to use heading tape in the heads up versus the old HIS with a hdg bug.
- Need TSTT trainer. MPDs have not eliminated the need for this.
- It's a criminal negligence that the navigation avionics suite on the AH-64A and now, the lord loves us. The AH-64D does not include sufficient equipment to navigate the aircraft within the national air space structure under IFR. Whoever designed the com....
- Too much info capability of equipment should not be confused with usability. Someone needs to remain focused on flying outside and the enemy.
- Remove ORT to 3rd MPD.
- Include amp in background.

Question 19. Please suggest any changes to the visual displays/instruments that might improve safety in your aircraft.

### **OH-58D**

- Same as # 15.
- Better ADSS/ODA.
- Separate control head for the MMS.
- Techniques of cockpit workload distribution.
- Heads up display.
- See #15. Plus add a third display for non-flt critical task, e.g., NAV, RAD 10 ATHS or IDM.
- Adj rotor RPM chicklers? The yellow lights are a NVG Distractor when flying there are always one/two chicklers? Showing....
- Location of MFK, keeps the crew member's "heads down" in the cockpit longer than necessary.
- Include a separate display with fight info. To alleviate screen switching.
- Adding airspeed, ait, radar on HSD. I would like to be able to select clutter level with the additional indications.
- The aircraft display tends to draw both pilots inside the AC. De-cluttering displays could help this.

- MFDs need new digital display not LCD.
- The radio frequency display (RFD) need to be a similar display to the MFD. The backlight for the RFD can make it difficult to read at night.
- We have to look in at the MFD too much especially during weapon engagements. We need to be able to put this info in a HUD or on the windscreen.
- Same as #15. More functions diagnosed and interfaced through amps results in simplify actions on software.
- With OH-58D the key is training so both pilots do not get stuck inside the cockpit at the same time.
- It requires self-discipline for pilot on controls to stay oriented outside aircraft. All pilots must be proficient on all systems and be able to function without help from pilot on controls.
- Less button pushing for hellfires ATHS.
- Make them as simple as possible. It is hard enough trying not to kill yourself sitting in the trees.
- Less glare.
- RFD brightness knob needs to be adjustable to make frequency darker.
- Keyboard placement in cockpit.
- the problem with the MFD's on the OH-58D is that they are so prominent. It is very easy to become fixated on the MFD. Unfortunately I have no solutions other than to emphasize good "cross check" and solid crew coordination.
- Make the display easier to interpret at a glance. Improve the screen quality to modern standard instead of 1980's technology monochromatic.
- Make it easier for crew to shoot.
- Windscreen HUD.
- Change max limitations to 100% (all limits).
- MFK re-designed, moving map display for MFD.
- The ADSS is too bright on dark nights.
- Change location of keyboard for ease of inputting data.
- Keep the value of each chicklet the same throughout the range of the gauge.
- Reliable velocity vectors.
- Add a VOR. Burn Rate info.
- Weapons systems utilization involves both pilots. Being focused on displays. My solution is a fixed firing device mounted on the Glare shield for rocket/0.5 cal. I already use it.
- RFD is usually inadequate NVG's.
- One of the side effects of this aircraft displays brings both crew members inside. Unfortunately this display is needed for our mission.
- possibly using different colors for each display on the VSD.
- More pop up menus like the Hog in the new CDs-4 would probably be helpful by increasing the ease of accessing various pages.
- Larger display.
- Use USI for 58D vertical speed. A back and forward key like internet. Touch screen.
- Heads up display which is NVG compatible to prevent pilot from being inside during critical gunnery tasks.
- LCD should have the capability to slew the angle of display that the pilot can adjust.

- Incorporate upgraded ODA symbology into CDS2,3 aircraft.
- Smaller MFDs.
- Remove the MMS pages from the pilot's side and replace with instrument flight pages.
- Better training- pilots need to keep their eyes outside the cockpit rather than inside. Also, using all ODA isn't always good or safe. If we focus on a certain element in the ODA display we could miss something that could be dangerous; even though we a...
- Our visual display instruments are great. Factor that need to change are pilots bring in too much attention inside due to complicated systems sequences and co-pilots inability to perform tasks. Keep it simple.
- Training and more flight time.
- Fuel flow high caution- OH-58D ® HSD has fuel pph indications. Caution should be added at 400+pph to indicate to aircrew that max fuel flow is close to being exceeded. Fuel flow mag. Max. out prior to any limitations being exceeded.
- A helmet sight system for the left seat (CPG) would allow quicker acquisition and less time heads down. This is especially true during aircraft movement as it would not be used during a deliberate search. Which is normally done in an OP and stationary.
- Hellfire engagements require both crewmembers to look inside. Very easy to lose situational awareness in the heat of engagement. OH58Ds back into trees entirely too much.
- Most accidents in this aircraft occur when division of attention. Both pilots are attending to same things at the same time.
- No problem with displays other than you have to look inside the aircraft to get information. When you are inside the aircraft who is flying outside?
- More heads up technology.
- Today's technology can provide an overwhelming amount of display. Therefore, visual displays and instruments should display only info pilot's need and can use not display info just to show information.
- Some systems are labor intensive drawing all attention of the CPG inside the cockpit.

#### AH-64D

- Improve back up instruments. Incorporate more FAA approved nav[agation] aids.
- The only negative is people focus on MPDs. This is human factors not MPD design.
- Moving map display with TSD. FAA approved GPS database for IFR NAV and GPS approaches.
- Place standby instruments higher on dash as well as make them larger.
- Possibly one additional MPD to increase immediately available info. More importantly, behavior modification training is paramount to prevent both pilots from focusing within the cockpit simultaneously, especially during gunnery/tactical trg.
- Second generation FLIR (possibly not your field).
- It would be nice to have engine page instruments displayed at all time.
- Standby instrument in the front seat.
- GEN 2 FLIR would greatly improve safety in the AH-64A/D.
- Removal of AH-64D CPG station "ORT" could improve safety. ORT Functions could be integrated into 3rd MPD.

- More auto-paging for emergencies.
- See #15 (I have 1.9 hours in the airframe).
- Get rid of ORT.
- Upgrade to Gen 2 FLIR.
- (Refer to previous recommendation.) Third screen and bezel button would reduce greatly the chance of wrong switches being pressed in the dark and reduce attention inside the aircraft of both pilots during missions.
- The installation of the emergency procedure checklist would increase the pilot ( not on the controls) ability to backup the pilot. Flying the Aircraft, much quicker keeping him more, situationally aware.
- GPS database that is FAA approved for IFR flight I.e., GPS approaches.
- Moving map display with color and terrain relief.
- Third MPD for back seat.
- Eliminate the ORT in AH-64D CPG station and replace with MPD. This would allow CPG to better divide focus inside and outside.
- Improve sight systems i.e., PNVs-FLIR, instruments package for IIMC.
- ORT is in the way causing you to move around in the front seat to see all of your info.
- Improved HDU.
- Unfortunately the MPDs cause fixation inside the aircraft.
- Glass cockpit design with VAB s and Fabs causes a greater need to be focused inside the aircraft.
- The AH-64D is well designed except as #15 above. The pages should have a schematic or layout to learn for ease of use prior to AQC training (that is web address format).
- In my limited experience, the ECS temp control should not be in the MPD. The reostat switch we had in the AH-64A was much more convenient.
- Replace ORT with a 3rd MPD. FLIR II System for better TGT I.D. (friend/foe).
- HDU by the BRY, sometimes day flying is difficult with HDU. Ability to go directly to page opposite crewmember is viewing.
- Unless you can find an MPD format to eliminate aircrew mistakes there is not much else to do.
- Remove ORT it is too bulky and blocks the view and accessibility to the MPDs. That is I can't reach the right MPD with my left hand while flying in the front.
- Maybe better sensors or sights.
- Voice activation to bring up pages quicker and not let go of the controls.
- Allow radar to look up for precipitation.
- More nomenclature.
- I've still got more than I can handle right now.
- Change PNVs Tads sensor/sight systems to FLIR GEN Z.
- MSL ALT could be added to transition symbology so you can reference ground track and ALT's at the same time or add velocity vector to cruise symbology.
- Not enough time in glass cockpit to make a determination.
- Remove the ORT to enable unrestricted viewing of both MPDs.
- IS at all possible reduce the level of pages. Make a pure utility main page and would love to have a touch pad instead of a thumb force controller.

- Moving map display. Upgrade TADS/PVVS FLIR.
- Put a third MPD in pilot station.
- More fixed action buttons.
- Bigger, make them larger if possible.
- Sort through page layouts, minimize stuck sub pages.
- MPD's and dashboard in backseat) are about 1-2" too low. As a longer legged pilot, I cannot use park brake in back seat and can't see all of MPDs in front seat.
- There is a lot more stuff added to the longbow than the "A" and only 2 MPDs.
- Industry standard GUI with a better access device to drive cursor/select. Displays need millions of colors not just 16 and have actual map (cadra/DTED/CIB) information below route graphics.
- Use analog instruments - a circled compass rose is generally missed. I used to just see 45 and 90 degree tick marks on the HIS. Now with only a hdg tape I have to do the math in my head for traffic pattern work.
- ORT needs to go now. FLIR needs upgrading now. Money is there but it is still not in my A/C. War is here now lets fix it. Also, goggle qual in AH-64D here.
- MPD would be better if they were higher about 3-4 inches.

Question 25. Please suggest any changes to the visual displays/instruments that might improve crew coordination for this aircraft.

#### **OH-58D**

- Move the digital/analog switches to a more user friendly position.
- Should be able to see the USD & HSD on same screen.
- Crew members are responsible for proper coordination.
- #2 for # 15 make both seats the same.
- Alert co-pilot when cursor is being used by other pilot with a[n] indicator on screen.
- I would like to be able to see what left seater is typing as they are typing. If I am up the same page without having to pull. The pull/back up on MFD.
- Make systems easier to use.
- Update CDS to improve changes between PIT and @2PO.
- We need new software so that the MFD can show multiple screens at the same time. Too often the right seater is looking over at the left seater's screen and vise versa.
- Maybe a simple visual indication(light) on the MFK to indicate which of the two pilots has cursor control to avoid stepping on one another.
- Have a pin for voice override pull pin and talk commands to display. Code for this can be integrated and easy to implement. Voice commands-weapons/hellfire.
- They are just intensive must discuss well in field environment.
- Duplicate functions on the MFD's.
- Side by side seating in the cockpit. Strongly reinforces crew coordination actions and mission information and from the visual displays.
- Sometimes it is necessary to use other pilots MFD mainly weapons engagement. The screen being set back from the frame can make some data not viewable from an angle.

- Actually the MFDs have a tendency to cause crews to over coordinate and bring their focus inside the cockpit.
- Central unit with all aircraft systems info[rmation] on it only.
- Use USI for 58D vertical speed. A back and forward key like internet. Touch screen. Totally independent system.
- Visual display pulls crewmembers inside the cockpit. Need more heads up displays.
- Glass cockpits have a bad habit of attracting the attention of both pilot and co-pilot/gunner when situation arises. Again the only change I could suggest would be awareness and training.
- Predicated on good crew coordination training.
- Many tasks are compartmentalized to individual crewmembers. Each concentrates on their individual tasks. Tunnel vision seems to be common. Maybe it is just the nature of the beast.
- Too many times crewmembers look across the cockpit to access info[rmation] on the other crew members MFD. Again who is flying the aircraft.
- Glass cockpit is not the cause of ACC errors, the basic ACC (cross monitor, backup, etc). The problem is if one pilot is working a task and the other is cross monitoring no one is flying. Acc[ident] training needs to be updated for glass cockpit and the school.

#### AH-64D

- A scratch pad for both crew to input data. Improvement to free text function and IDM messaging to ease use.
- No ability to monitor the opposite crew member's symbology/Actions.
- Small window stating what MPDs. Pages are up in the other cockpit.
- Crew coordination is made more difficult because the front seat pilot must devote much time to setting up the battlefield properly, the pilot in the back seat does not see changes as they are happening.
- At the different station crew members can make changes and if the other pilots is not looking at that page he/she will not know it has been changed.
- Would benefit crew-coordination if crewmember could view other crewmembers MPD, see exactly what the other is viewing.
- More independent crew station separate MPD functions to force crew coordination.
- A method is required by which one crew member could see another crew members display.
- See #15 (I have 1.9 hours in the airframe).
- The design do[es] not promote crew coordination. The crew members must initiate crew coordination.
- Have function in pilot's station that allows him to see what CPG is doing on his MPD's.
- Change indication of the page displayed and functions selected by one crew member when the same page is viewed by opposite crewmember. This would help avoid continually selecting the same function by both crew members at the same time.
- Visual displays not only promote good crew coordination they necessitate it.

- Add another system page that indicates which crew member has control of certain systems (i.e., color code or identify who has PNVs/TADS, who has certain weapon selected). Add another icon on UFD to indicate when crewmember is transmitting on a given radio o...
- Replace the ORT on the longbow with another MPD.
- Crew coordination is a much bigger issue with the AH-64D due [to] the MPDs and the ability for each crewmember to make changes and decisions separately from other crewmembers.
- Develop a link function for one crew member to display another crew member's exact MPD page on their's.
- Crew coordination training is needed for glass cockpit aviators, not redesign.
- Crew coordination is on the crew. The MPDs only trigger or remind them to coordinate.
- Cockpit unique controls that cannot be manipulated by the other crew member.
- My low experience levels does not give me much to draw a good conclusions.
- Not enough experience to give a suggestion.
- Limit the button "step-ons" two pilots up same screen, press button, and counter each other.
- There seems to be too much duplication between what each crewmember can do. That is good in many ways but it requires strong crew coordination to make it work.
- None at this time.
- Fixed action button to (illegible) page or a different access via a z axis aspect as we have with flight page.
- You must have crew coordinator because of all the common button.
- Indication in each crewstation, on each page, as to what pages the opposite crewmember is on.
- The MPD's do not promote good crew coordination but they require better coordination in order to be safe.
- In cockpit camera maybe?
- Being able to see what the other guy is doing (what pages he is looking at). Ability to pull up the other guy's pages.
- Video select position for monitoring opposite crewmember screen selection.
- Need to see what the other person is looking at, at any time.
- The challenges of crew coordination posed by having a/c common switch settings are significant, but off set by the ability of either CM having access to the switches.
- MPD's cannot be monitored because so much is station specific but impacts on entire flight, if is great anyone can change it but by sharing all duties it increases crew coordination duties/verification in order to ensure info is not lost or missed.
- Not enough time in glass cockpit to make a determination.
- Having a third MPD in both cockpits not just the proposed to replace the ORT.
- Add a capability for each crew station to know what the other crew member is displaying.
- Ability to view other crew members pages.
- With inexperienced person in cockpit workload increases ten-fold for other crewmember. Need more training devices(i.e., TSTT) that simulate full cockpit without wasting blade hours.
- It would be beneficial in some cases to have some indication of what is cockpit related as opposed to a/c-related when making input on MPD's. But crew coordination still has much less to do with the hardware that with the training of the crew.

- Crew coordination is a must in the A/C.
- Analog combined with heads up would be great. Maybe put a small compass rose in the heads up with a wind arrow on it.
- Remove ORT, replace it with a small screen with fixed flight symbology period.

Question 32. Please suggest any changes to the visual displays/instruments that might improve situational awareness for this aircraft.

### **OH-58D**

- Better ADSS/ODA sys[tem].
- Change the monochrome MFD displays to color to allow the ability to depict topographic information.
- We need a sys[tem] that will acquire info[rmation] faster.
- Be able to slew the sight to where the pilots are looking.
- Digital roaming map that has the A/C position plus the position of fellow/team a/c.
- We need a small HUD on both seats.
- ADF.
- Side by side displays of HSD and VSD.
- A third MFD would add greatly, that way we could always have up the HSD page.
- A mirror to see behind you or t-rotor when doors are on. Change visual display of Apr39/AVR2 into HSD. If threat is serious copilot HSD should change automatically with clock dia/dist and threat current system is ignored a lot and not effective.
- Iron out software discrepancies between, MPD TGT/TQVSI and MFD's.
- Better cockpit procedure trainers. When spending time in cockpit it is for helping weaker pilot stumble through pages.
- Selector switch on MPD does not always work on first press. Recommend switch with lower break-out force.
- Crew proficiencies of A/C systems and mission/cockpit. Workload greatly determine[s] inside/outside time and situational awareness.
- Have TQR's brighten when approaching limits.
- Some things just can't be replaced by displays/instruments i.e., obstacle clearance.
- It takes a little time to access some pages in a timely fashion.
- Changes need to be made for weapon fire pages. So both pilots don't have to be in the cockpit at the same time.
- Add moving map display with weather radar improved non-corruptible GPS.
- For NR make the instruments match each other, i.e., the MPD, the MFD, the VSI. Mast torque will not register a warning until ABDUE103- yet the limit is 100-116.
- Moving map.
- Moving map display. Moving waypoint in buffer? PFLAN.
- Actually the MFDs have a tendency to cause crews to over coordinate and bring their focus inside the cockpit.
- Comsec indications.
- Closer correlation between instrument indications (scales) and actual ACFT limits.



- Only issue is that the display information is so good that it tends to bring pilots inside a little too much. Crew coordination and discipline can control or prevent this.
- RMS in all version of CDS 2,3.
- Fix the tuning problem that occurs when radios are tuned on the RFD but not in the radio and add up chan[nel]-up chan[nel]-down capability to frequency HOP.
- More dependable, less confusing to navigate and use.
- Caution warning systems, CDS need to have a audio hierarchy, the aircraft is too noisy during an emergency. EX. ENG out is displayed with audi, A/C Gen fail should display but not be accompanied by an audio.
- Fuel flow high caution- OH-58D ® HSD has fuel pph indications. Caution should be added at 400+pph to indicate to aircrew that max fuel flow is close to being exceeded. Fuel flow mag. Max. out prior to any limitations being exceeded.
- Upgrade all ACFT to OH-58D® standards the most helpful subsystem in the RMS.
- Some type of modernized head up display.
- Moving map display would improve situational awareness.  
Heads up display for critical flight info[rmination].

#### AH-64D

- Moving map (contour lines, vegetation, satellite imaging on TSD. Increase response time of ENG/ASE autopaging display. UFD display of exceedance info.
- Map underlay! Now you just follow lines it draws you inside a little too much there is too much to see on the inside.
- Possibly include other pages on HMDs.
- More autopaging and more selections per page MPD page structure goes too deep.
- See #15 (I have 1.9 hours in the airframe).
- Upgrade to Gen 2 FLIR.
- Too many menus/screen. Actions that used to take only the push of a button now take longer since we are forced to navigate through multiple "pages."
- A moving map should be incorporated as an underlay on the TSD page.
- Moving map display.
- For performance planning make the calculations more accurate and reliable and if possible dynamic throughout flight period.
- Standby instruments for the CPG station.
- Makes you focus inside more than outside.
- Again the MPDs bring you inside. An excellent tool though for A/C performance situational awareness.
- Moving map display underlayed on TSD page.
- Seems both crew members can get sucked into the MPDs and nobody looking outside. "SA" training can counter this.
- Confidence will come with time if the displays prove reliable.

- Falcon View 3.1.1 would be a great addition to the situational awareness through map database management 1:500000, 1:250000, 1:50:000; DTED, IM CIB. (Route analysis, terrain analysis, ABF/BP analysis during MSN chngs).
- Integrate more combined arms/joint aspects so we can tack to or get info from the right square at the right time.
- Display an MSL attitude in transitor mode of the HDU. Just a suggestion that bothers many pilots even though it isn't panel mounted.
- As stated earlier glass cockpit on AH64D is a huge advantage and allows crewmembers to focus more outside A/C.
- MPDs promote more time inside the cockpit. In my 1-6 hr flight yesterday, I was probably outside for 0.2.
- Moving map underlay with elevation data, real-time emitter download from an external source with LDS information displayed.
- I answered neutral on several of the above questions, once again because of my relative short time in the aircraft and all of it is pretty overwhelming at this point.
- Put Eps in aircraft.
- The only place on HIS is allowed is on an already cluttered NAV/Attack page, either an analog HIS or glass HIS should be added to allow P and P to determine his position relative to sit without thinking with heading type.
- Not enough time in glass cockpit to make a determination.
- Put a third MPD in pilot station.
- NR and NP reference displays are too slow from the time it takes to set from the engines and NR sensor to the displays.
- I am still tied to a large and cumbersome paper map, requiring that I now divide my attention yet once more.
- Improve visual display from FLIR. FLR - the number of false targets.
- Both seats need a fixed digital or analog B/V, flight symbology on DASM.

Question 36. Please suggest any changes to the visual displays/instruments or AQC training that might improve learning to use the visual displays/instruments in your aircraft.

#### **OH-58D**

- More training flight and training simulators.
- Utilize sys in every aspect and capability.
- Cockpit training and going through senarios w/ our IP's was the most beneficial. You were able to learn techniques as well as procedures.
- A full up sim for the a/c.
- Need to integrate tactics since the new pilots we receive have zero tactics in this or a similar a/c.
- "Hot cockpit" tng more accessible.
- There's nothing like learning on the job.
- More flight time. More money and time in units to train between missions.

- Make more simulator[s] available for crews to train on.
- More time flight school as a whole is too rushed in the vain attempt to crank out more aviators. Longer, more comprehensive training is the key to a deeper more ingrained sense of how to function in the aircraft.
- Fly more hours in AQC. Simulate BAG at navy Flight Training after flight school. Standardizing all OH 58D missions. That way you RID RL unit readiness. After the Rag you are RL1 DIC at any unit and ready for and attack over water missions etc.
- Better cockpit procedure trainers. When spending time in cockpit it is for helping weaker pilot stumble through pages.
- Have same software in the CST's as in the helicopter.
- IDM need to be cleaned up meaning navigating the pages could be much easier.
- The drop in proficiency is not due to aircraft systems but due to the lack of time Aviators spend in the cockpit, especially commissioned officers.
- Get rid of computer based training. Train on the ground with instructors and cockpit simulators.
- Have more simulators, more real life simulators.
- Too many software changes 'I' model Vs. 'R' model.
- More explanation from actual users than the CST trainers.
- Upgraded software in the 58D simulators for AQC training will better support the learning of the visual displays in the a/c.
- There is no substitute for flight hours.
- How about a motion simulator? That CPT in AQC is okay for some things, but not power management/awareness.
- More flight time.
- Current software in AQC moc ups.
- Stop focusing on the situations. Use common illegible use. Teaching more mission illegible using individual tasks.
- Keep training software as up to date as the software in the Aft.
- Full motion visual simulator.
- More time than in ACQ using systems.
- Current field software ad aircraft (R3, CD54).
- More training flight time.
- Need simulators.
- 4
- A classroom instead of computer learning. 58D in Aqc is in trouble.
- Additonal time in aircraft.
- Right now the AQC students are learning with CPT's that are a software versio behind the current software at the flight line.
- Update and keep updated simulators and computer based trainers. Have them available at any time for the student.
- The problem is not the instruments or Ft. Rucker, it is time provided for practice.
- FPTs must be the same as the aircraft I.e., JUMF CDS4 software. Focus more on system use in AQC instead of the old you're a drop of oil game.

- A fault system generation program for actual aircraft while conducting "Hot cockpits" training. This would teach aviators to notice and respond to emergencies and IPs a chance to evaluate the aviators' response.
- As a unit in the fielding process it would have had a huge impact on training to have had the CSMET or CPT on the front end of training.
- Procedural simulator at the unit. We need to push buttons.
- The glass cockpit is a great concept. The Army needs better training aids I.e. simulators to train on.
- Ensure mock ups are upgraded along with the aircraft- training simulators are too often outdated.
- Increase ATM iterations of tasks. Increase flying hour mins. Develop a full motion simulator.
- A full vision simulator will help.
- More time in mock up.

### AH-64D

- Mock up.
- The design of a more accurate "emulator" that can be issued to each student. The current emulation software has many anomalies.
- More hands-on training with aircraft or LCT would benefit learning process.
- More MPD hierarchy training.
- Keep the PC training emulators current with A/C configuration and distribute to students.
- More time in the LCT before going to the flightline.
- Provide MPD mock-ups for practice. Alternatively, computers with MPD emulator should also suffice.
- The 64D has limited access to the training simulator, there is a lot of procedures that cannot be practiced with computer software emulators.
- More hours less time spent on non aviation duties to include warfighter, airborne ops, parades report of survey's etc.
- Actual MPD's in classroom environment that operate like the actual equipment.
- Have Boeing produce an emulator that actually works as it does in the helicopter.
- More time pushing buttons on emulator or simulator.
- Make a longbow static cockpit so that students can go over the start ups and MPD pages on their own time.
- If AH-64D AQC students could have access to LTC on the weekends or have available "mockup" cockpit at the learning center.
- Come up with a standard computer disc that works on all computers and can do all the functions of the acft. There are at least 5 emulators floating around.
- LCT periods need to be increased to at least two hours in duration each. Also, more periods should be allocated so more time can be spent not just getting introduced to what things look like, but also so students have time to employ what they think they....
- Need cockpit mock-up to get used to symbology.
- We need a switchology trainer similar to the AH-64A TSTT to practice on.

- There must be more training aids. For example, it is impossible to have access to addition LCT time. Student need a partial simulator especially for the CPG station for gunnery operations.
- Run actual mission scenarios during class computer training to increase positive habit transfer.
- Have a trainer (push button type at the Ed center for students.
- More LCT time.
- Software programs issued to each aviator and LCT time, ACFT increased.
- Need to have a mock up for blind cockpit procedures. Split LCT (SIM) periods so they are not back to back to allow discussion. Increase flight line flights to 2.0 instead of 1.4 to allow more interactions of tasks in the A/C.
- Distribute simulator like the Air Force and Navy do to help out.
- Scenarios built into the computer training programs for performing a variety of tasks.
- Emulator that is true to software version issued to every student. TSTT device similar to AH-64A TSTT.
- Must practice or use to maintain proficiency.
- More simulator time.
- Develop a TSTT for the AH-64D.
- Have an MPD mockup like the TSTT.
- A computer-based MPD emulator for personal use that is current to the aircraft without glitches.
- Updated computer trainer "LPT" for practice at home or on computer.
- Better, more accurate home computer emulators, or something in the way of a C-WEPT type device that students can use without having an IP there.
- It is a shame to see so much money spent on computers in the classroom. Instead of paperweights, we should use these aids and incorporate them into the curriculum.
- There is a strong need to have some type of training device that the students can get access to similar to the TST of the AH-64A model.
- A better emulator (computer based program) that allows full functional use.
- MPD emulator. Need a TSTT for longbow.
- A well-developed interactive computer program that loads on any home computer with actual pages.
- I have difficulty using computer training programs. Prefer having an instructor.
- If they could have a mock-up at the learning center like the AH-64A mock-up, that would be nice.
- Practical exercises dealing with WPNS, DMJ, commo, and NAV w/ interactive emulator.
- Have better MPD simulator.
- Get a new up to date emocator that works on regular basis.
- Some kind of a TSTT would definitely help. The only thing available now is the LCT and that requires an IP.
- Better and more complete have computer based display simulators.
- Have an MPD computer program in the learning center. Create a Longbow TSTT. Have more LCT time, get rid of supplemental course.

- We need a switchology trainer TSTT. The emulators are nice but don't teach switch positions.
- Provide system similar to TSTT. Make available to students at all times.
- Provide an accurate emulator to pilots. Instructors should teach classes in LCT to solidify class courseware it should not be the first time try in the acft.
- Not enough time in glass cockpit to make determination.
- Need a TSTT similar to the AH-64A.
- There should be more training in simulator provided for supplemental AH-64D.
- Correlate academic instruction with a flight line instruction I.e., when we're learning weapons on the flight line, teach weapons in academics.
- Need a TSTT type device to practice all MPD ops which include grip and ORT buttons/switches.
- Set up a system similar to the AH-64A TSTT for the longbow. LCT is good training but is available as much as the aircraft not too often.
- We need a trainer like the TSTT for the A model. I don't care about the cost it's essential to training.
- Put out up to date and accurate lot number computer training programs.
- Allocate more flight time allowances for unit level proficiency.
- Let pilots be pilots. The number of additional duties today is outrageous.
- Need realistic training CDs for the use of the MPDs.
- We badly need an updated emulator that will work reliably on newer computers, and much greater access to the LCTs.
- The emulator software is referred to by both the classroom and flight line as invaluable and essential to mastering the AH-64D. It will not run on half of the computers that my class has (personal). Laptops (that work) should be issued to students with i....
- Change academics to teach what you need to know in order to operate the A/C. Who cares that the speed of light is 186000mi/sec.
- Develop a TEAC for AH-64D.
- TSTT!!!
- SUPP course needs expanding 8 weeks.
- Up to date computer training GD(s) to permit students to practice after class.
- The Ah-64D needs a TST.
- LCT device similar to TSTT (full mock up of cockpit).
- More flight time.

Question 38. Please use the space below to mention any other opinions you have about the visual displays/instruments on this survey.

### **OH-58D**

There were no responses to this question.

### AH-64D

There were no responses to this question.

Question 42. Please suggest any changes to the MFD that might improve the visual displays/instruments.

### OH-58D

There were no responses to this question.

### AH-64D

There were no responses to this question.

Question 45. Please suggest any changes to the MFD that might improve the transition process for this aircraft.

### OH-58D

- More hands on tng less cst.
- Heads up target acquisition system. During engagements current software promotes both pilots being sucked into cockpit.
- Better backlight for standby turn and slip indicator.
- Easier software. Define user REQ's before writing code. Send software personnel to units to go over by item what users would like. Also voice integration would be easy to do as input and screening mechanism already in place.
- Keyboard to enter information could be in a better position.
- More simulator time, develop better simulator and maybe a flight simulator for the aircraft.
- Make the system lighter also improve the ADSS for 58 pilots.
- Again, flt time is the most important element. Perhaps a multi-ship tactical mission in the AQC could help make students aware of the need to have systems operations down cold.
- The instruments are easy -it's the stupid limits and time restrictions that make it complicated. If 100% meant 100%-life would be so much easier.
- With respect to question 44 , the questions are like comparing apples and monkeys. I picked the OH-58 A/C as safer than the OH-58D because it auto rotates better not because of instrumentation. The only question that I really answered based on instru....
- Continue to stress crew coordination and keep 1 set of eyes outside.
- Simulators.
- Possibly distinctive icons where appropriate for faster identification of critical buttons or switches.
- CPT's that match the aircraft (CBs software).

- The OH-58A/C does have a much lower workload with reference to cockpit display, but also has much fewer systems and a greatly reduced capability.

### AH-64D

- More MPD training on the hierarchy of how the pages flow. If you know how to get to a page quickly, the MPD tells you what to do there.
- See #36 (More time in the LCT before going to the flightline.)
- The AH-64D Aqc should have a workable computer simulation that can be distributed on ACD to the students.
- A higher quality NVS would best promote safety. I am concerned about all my instrumentation being provided by MPDs.
- Give this questionnaire again at a later date to same individuals to see how opinions change as they progress after training.
- We need training programs/ trainers to practice.
- More flight time in aircraft.
- Should have backup instruments in front seat. More training should be available, more flight hours.
- There will be accidents caused by MPDs. It is inevitable.
- More flight time.
- A training simulator that is up to date with the aircraft available during training and AQC.
- More computer simulation, and LCT time.
- Classroom - More computer or MPD operation (switchology); LCT- More hours (procedures); A/C -More hours (tactics).
- Practical exercises with an interactive emulator.
- Although this is valuable information. I think you [would get] more intuitive responses if this was given to the pilots that have flown the glass cockpit for at least a year. I am sure if I was given this next year some of my opinions might be different.
- The low rating for safety is because, at this point, I am "inside" the cockpit more than ever to learn the system. I feel that we need more LCT time, more so than flight time, for more "button pushing" experience and a chance to better learn the pages.
- I'm currently in transition course, ask me this information in about one year after flying and teaching the aircraft and course.
- Promoting better Cc and making less intrusive ave two different things, yes work can be divided up. But also means more are apt to be forgotten or missed.
- Not enough time in glass cock pit to make a determination.
- Allow more time for training and have a station for MPD manipulation.
- Repetition is the key to success. The more times you perform a given task, the easier it becomes.
- Looking forward to have moving map display for greater situational awareness in the near future.



- We are very new to the AH-64D, our interaction with it and the various systems is what is completely new to us. After flying and some experience in the cockpit. Push-in buttons and learning how to crew coordinate actions and employing the machine. I belie....
- TGT and triple TAC standby instruments.
- More flight time. LCT time and classroom time.
- Traditional cockpits are easier for awareness of the flight environment simply because there are less distractions.
- See #36 and add three exclamation marks.
- Let me take this survey one year from now. Answers will be different because of higher experience level.